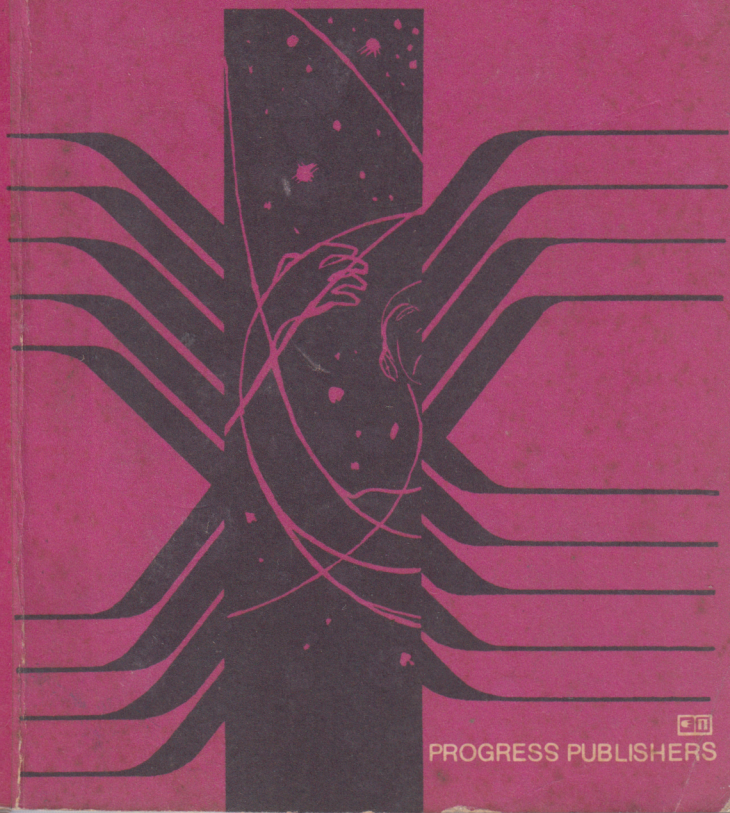


KIM SMIRNOV

# FAUST VERSUS MEPHISTOPHELES?



PROGRESS PUBLISHERS



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Translated from the Russian by *Peter Doria*  
Designed by *Yuri Luter*

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**ФАУСТ ПРОТИВ МЕФИСТОФЕЛЯ?**

*На английском языке*

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## Prologue

I love the University Embankment in Leningrad. Its sphinxes. The bookstall by the Twelve Collegia building. The gentle rolling of the Neva's waters against the eternal immobility of the granite. For some reason I particularly like it here not during the White Nights, but in autumn, when fine drizzles are frequent and yellow maple leaves appear from God knows where on the wet granite.

Perhaps there is some connection; anyway I feel it is here, right by the sphinxes, on the embankment, that the idea came into my mind to write this book.

While on a business trip to Leningrad I stepped into the Leningrad University library to look up the pages on Homunculus in Goethe's *Faust* for purely scientific reasons, in connection with the theme on genetic engineering. I really got involved, however, and I spent several more hours in the reading room and read the entire tragedy. Later, strolling in the rain along the embankment, I thought about the magic of the "eternal book", wondering why I had been stirred and gripped unremittingly by the old story which I'd known since my student years.

And suddenly I realised why. Because it holds true today, too. Because Goethe's *Faust* offers perhaps one of the first serious disputes on the knowledge and morality theme and at the same time a key to the moral problems faced by science today.

The bedrock of *Faust versus Mephistopheles* is dialogues with prominent Soviet scholars on a number of these problems. In real life, of course, these dialogues were not always devoted to the morality theme. Normally, the assignments of the newspaper where I work dealt with new scientific investigations. Nevertheless, the talks inevitably transcended the framework of how to explain in simple language formulas, models and principles underlying new ideas, chemical reactions, experimental units and machinery. Quite often these tangent questions touched precisely on moral issues. I feel this is due to the fact that they persistently remain in the spotlight of public attention.

A number of lengthy debates on knowledge and morality were conducted in the newspapers *Komsomolskaya Pravda* and *Literaturnaya Gazeta*. For the past two decades this topic has been invariably tossed around in Soviet socio-political, philosophical, scientific and literary journals. It has been analysed in a wide range of major research works, articles and monographs.

This book does not claim to examine the problem systematically and in all its facets. Its aim is more modest: to present a dialogue between readers and scholars on moral aspects of cognition.

To avoid any misunderstandings, I want to point out that the questions put to scholars in

this book are not my own. Furthermore, I do not agree with the authors of a number of questions and would have phrased some of them differently. However, they are quoted here in the form in which they were asked in letters sent in to the newspaper *Izvestia* by industrial workers, young researchers, students and pupils, trainees from vocational schools and in notes obtained at meetings with readers. The answers to these queries provided by scholars comprise the heart of this book. However, I have not confined my role in the book to that of a conscientious intermediary, translator or stenographer, but have arrogated to myself the right to express my own views on the readers' questions.

But this is more than a dialogue on knowledge and morality; it is also a story of the creators of modern science.

In medieval times, the abilities to ride on horseback, swim, throw a spear, fence, play chess, and write and sing verse were considered the seven knightly virtues. Today, the initiation of the "knights of science", as Academician Nikolai Semyonov has called scientists, puts much loftier and more difficult requirements to them, and in the moral sense, too. What is involved here? What is the moral credo of today's Soviet scholar? This is what the book is all about.



Is parchment, then, the holy fount before thee,  
A draught wherefrom thy thirst forever slakes?  
No true refreshment can restore thee,  
Save what from thine own soul spontaneous breaks.

Goethe. *Faust*



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## FINDING A ROAD

Faust's praise of "live" knowledge, as opposed to book knowledge, unwittingly draws us to Goethe's work itself. Has it, distanced from us by many decades, today, too, become the very same parchments which are frequently revered but rarely read? Or perhaps Goethe wasn't entirely correct...

Today's scientific world is much more complicated, colourful and richer than the one which opens up before us in Faust's cell. His flasks and magical pentagrams have nothing in common with modern accelerators and space stations. However, in today's discussions on where science is going and how it interacts with morality, it is not fortuitous that the name Faust from Goethe's tragedy is mentioned so often alongside the name of Galileo Galilei from a play by Bertolt Brecht. This hardly would happen if Goethe's work did not contain the idea of two possibilities, two paths of cognition, if there did not pulsate the fount which feeds present-day reflections about the moral aspect of our fresh knowledge about the world.

The tragedy of Faust, as one scholar has pointed out, lies in his aspiration for the absolute, for knowledge cannot have a "mass at

rest”.<sup>1</sup> An instant cannot stop and become a “moment of eternal truth”, just as a photon cannot stop in flight.

Mephistopheles’ plan consists precisely in forcing Faust to declare the relative to be absolute, to accept any mirage or surrogate of the truth as the meaning of life, as the ultimate truth in which he, Mephistopheles, himself does not believe, for he “knows everything”. His environment is the destruction of everything which elevates man; it is the belittling of his aspiration to spiritual heights, the shattering of his illusions, his fall into sin. For Mephistopheles the very meaning of existence is caught up in pathos, in the apotheosis of negation, as in a vicious circle.

This pathos is even present in the very idea of Faust’s temptation. Leading Faust through the full gamut of earthly and “otherworldly” temptations and illusions, Mephistopheles is convinced that there is no such thing as holy people, that any man will definitely stumble somewhere along the line, and that knowledge itself will lead to the cheapening of morality.

Outwardly, he triumphs in the end. Faust has taken illusion for reality. He thinks that at his will people turn yesterday’s sea into flourishing land. But it only seems to the blinded Faust that people are digging canals. In reality lemurs are digging him a grave.

From the standpoint of Mephistopheles’ destructive concept, the victory was his. Moreover, this also seems to be confirmed by the number of Faust’s moral defeats—from the death of Mar-

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<sup>1</sup> See I. Zolotusky, *Faust and Physicists*, Moscow, 1968, p. 7 (in Russian).

garita to the demise of the old men who had supposedly been sacrificed for the great idea of universal happiness.

There is another, deeper, truth of this finale, however. Admittedly, it is one reached at the cost of severe trials and errors, the cruel cost of cognition. Faust did not find ultimate truth. But he did come upon a path that can reasonably be followed, a goal for which one can reasonably give up one's life: transforming the earth into a flourishing paradise, and humanity, into a creative rather than destructive force on earth.

Faust arrives at this result "of everything that the mind has amassed". This is also the conclusion drawn by Goethe himself, who in *Faust* has capsulised all ages, all human civilisations and has given them over to cognitive reason for judgment. He names not only the goal to which the acquired path leads but also the vehicle for reaching, the means of turning illusion into reality:

He only earns his freedom and existence,  
Who daily conquers them anew.

Mephistopheles does everything in his "inhuman" powers to prevent the elevation of man with the aid of cognition, to hold him at the level of analysis and, after being tested by illusions, to dash him down into disbelief. And he does achieve a great deal. However, man's reason, his will and struggle overcome the "diabolical" principle in cognition.

Goethe seems to be questioning the union between cognition and the evil spirit preached from time immemorial by religions of all stripes in different versions – from the crudest and cruel-

est to the most sophisticated, from the fires of the Inquisition, which burned books by heretics and the hearts of their authors, to the verse of Ecclesiastes: "For in much wisdom is much grief: and he that increaseth knowledge increaseth sorrow." And for this reason, in the age-old controversy over what purpose cognition serves, Goethe, while not closing his eyes to the fact that it can also serve evil, does, in the end, in the ultimate choice, put it into the camp of good.

There once lived a certain Johann Georg Faust, a graduate of a higher school of magic. He was born in 1480 and died in 1540 from an explosion during an alchemy experiment. There is even a monument to him erected in his hometown of Knittlingen in front of the guildhall. Incidentally, Goethe himself knew nothing of this man's existence, surmising that he was drawing on a folk legend. Nevertheless, the Faust-Mephistopheles controversy had begun even earlier than the real Faust's birth and it continued when Giordano Bruno stated: "People will judge me correctly where scientific research is not insanity, where honour lies not in voracious seizing, luxury not in gluttony, greatness not in wealth, truth not in wonders, sensibility not in malice, kindness not in treachery, caution not in deceit, the ability to live not in pretence, and justice not in tyranny and coercion."<sup>1</sup>

This controversy is not a simple one and has yet to be resolved. Naïve were the hopes of many scholars who believed at the turn of the century

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<sup>1</sup> See *Treatise on Science*, Moscow, 1976, p. 24 (in Russian).

that the revolution in the natural sciences would bring mankind only good news and fruit. The very definition of good and evil as regards science and its discoveries makes sense solely when it is clear which social forces stand behind these notions. It is not fortuitous that it was the major imperialist powers that were the initiators of all the inhuman uses of scientific breakthroughs—from gas attacks in the First World War to atomic bombings in the Second.

No ruses of bourgeois propaganda are capable of making mankind forget that it was the great theoretician and architect of socialism Vladimir Ilyich Lenin who proclaimed: “In the old days, human genius, the brain of man, created only to give some the benefits of technology and culture, and to deprive others of the bare necessities, education and development. From now on all the marvels of science and the gains of culture belong to the nation as a whole, and never again will man’s brain and human genius be used for oppression and exploitation.”<sup>1</sup>

In the 20th century, the antiquated legend of Dr. Faust, the scientist who sold his soul to the devil, has become a very concrete and real rivalry of social ideas and social forces. Has not the eternal drama of Faust been repeated at a new stage in history, when physicists, who are moved by the dream of giving people the fire of Prometheus, new and unparalleled energy for creative endeavour, are suddenly horrified to see that they have opened up the way for the birth of the atom bomb and that latter-day Mephistopheles are prepared to use it without thinking

<sup>1</sup> V. I. Lenin, *Collected Works*, Vol. 26, Progress Publishers, Moscow, 1977, pp. 481–82.

twice?

Another unique quality about the drama of Faust, the drama of a scientist, is that he himself is not an unconditional personification of good, that the rivalry with Mephistopheles also takes place in his soul, and that in it Mephistopheles sometimes takes the upper hand. Faust is the personification of cognition before whom two roads, two possibilities of establishing one's truth are opened up.

There has always been a fierce struggle, and especially today, around the moral precepts of science; it is uniquely embodied in the scientist's personality, his world view and principles. The roots of this struggle are hidden in the socio-political polarisation of the modern world, in the rivalry between communism, to which the future belongs, and capitalism, which is becoming obsolescent but is doggedly clinging to life and is using every means at its disposal (including scientific ones, paradoxical as it may seem) to prolong its existence.

If one examines the positions of individual scientists living in various countries on all five continents, they will present a very diverse and conflicting picture. Nevertheless, a common pattern is taking on increasingly definite contours: it is socialist society that is acting the role of the most consistent and actual defender of the moral foundations of science and asserting the latter's purpose as serving humane aims. This pattern is directly connected with one of the main facets of the building of a new society—the communist education of the individual, of his lofty ideological and moral qualities, and with the triumph and flourishing of the fine moral qualities in man.



Conviction gathers, truer, nearer!  
The mystery which for Man in Nature lies  
We dare to test, by knowledge led;  
And that which she was wont to organise  
We crystallise, instead.

Insane, at first, appears a great intent;  
We yet shall laugh at chance in generation;  
A brain like this, for genuine thinking meant,  
Will henceforth be a thinker's sure creation.

Goethe. *Faust*



## THE SCALPEL OF KINDNESS

The words adduced in the epigraph are uttered by Wagner, an ordinary, mediocre individual who, even in creating the artificial man Homunculus, fashions something inanimate, incapable of living outside a flask, in communion with the world. That is, he in effect creates a still-born being. And isn't this very counterpoising of the artificial to the natural evocative of the modern odes to "thinking machines" and sensational reports about test tube babies?

I am not at all implying that today's scientists are far from the boundary which Goethe talks about as being insurmountable, beyond which is wonder. We know what wonders modern biologists are capable of. Yet even today their actual work is indeterminably far removed from the lightness with which latter-day Wagners interpret the successes of genetic or cellular engineering, literally repeating the sentences of their literary prototype:

...This procreation is most rare:  
Of the old, senseless mode we're now well ridden.

It is not by accident that Mephistopheles responds to Wagner's philosophising with a vile jab, to the effect that it isn't all that unprecedented a revelation:

I've seen already, in my years of travel,  
Much crystallised humanity.

The only paradoxical thing is that scientists who conduct experiments with the conception of life in test tubes are immediately dubbed "modern Doctor Fausts" by journalists. Even though it is Wagner who is involved in these experiments in Goethe's work; Faust at this time is engaged in completely different pursuits: he raves about Ancient Greece and the beautiful Helen...

True researchers working today "on the verge of a miracle" are very exacting toward themselves and their work and the comprehension of its results. And when our talk ended with the prominent Soviet chemist and biochemist Yuri Anatolievich Ovchinnikov, Vice-President of the USSR Academy of Sciences, Lenin Prize winner and Hero of Socialist Labour, he said with what seemed to me to be relief:

"Thank God you didn't ask about transmitting thoughts over distances."

"People ask such questions?"

"Quite frequently! Especially school-children."

Today Ovchinnikov is a famous scientist. But he started out with chemistry lessons, with the first experiments in the school laboratory. He talks about this, addressing young people going into the science field: "...I was really enamoured of the world of colourful transformations, snow-white precipitation and shining powders, unexpected bubbling, at times dangerous explosions, enigmatic odours and walls of smoke. Somewhere deep inside of me I imagined myself almost an alchemist persistently searching for

the philosopher's stone. Reflecting on the world of chemistry, groping through the little-known labyrinths of Mendeleev's table, and at times wandering into the realm of rare-earth and transuranic elements, I found myself more and more bewitched by the kingdom of amazing substances and their complicated transformations. Together with Wöhler I was crossing the threshold of inorganic and organic chemistry and convincing myself of the mythicalness of the "life force". Together with Pasteur and van't Hoff I tried to comprehend the laws of asymmetry and chirality which divided the entire world into left and right... I wandered through inconceivably complex structures of compounds encountered in fauna and flora, and dreamed of the day when I would be able to understand their purpose at least a little...

"However, the real world of my school laboratory was not so glittery. Things frequently went wrong, experiments failed, I would drop test tubes and flasks, and the burns would constantly remain as birth-marks of sorts on my hands. Chemistry came hard to me, it punished me severely for my mistakes, it disillusioned me; however, as is often the case, I was soon afterwards forced to admit that I had grown to love chemistry. It was a true first love."<sup>1</sup>

Perhaps surmounting difficulties for the sake of love really was the source of this scientist's later accomplishments. Without getting into that, all we'll point out is that then, during his

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<sup>1</sup> *Lenin, Science and Young People*, Moscow, 1980, p. 243 (in Russian).

school lessons, the future academician was already thinking about the animate and inanimate, about the mysteries of life. It was with the following question pertaining to this theme that our conversation began.

*Question 1. Do we have the right to experiment on life, be it the life of a monkey, dolphin, dog or laboratory rabbit?*

Yuri Ovchinnikov answers the question with another question:

“But for what do scientists conduct such experiments? The loftiest purpose and prime object of the science of biology is to serve man. And medicine has a vital stake in absorbing breakthroughs of modern biology.”

And this not only applies to biologists, Academician Ovchinnikov believes. Chemists, physicists, mathematicians and technicians relate to man in the same way. Understanding man and serving him is the highest goal to which scientists, experimenters and theoreticians aspire. The most theoretical, the “purest”, science is ultimately subordinated to this aim. The only question is whether it will serve man today, tomorrow or in the rather distant future.

“I am a proponent of an experimental attitude to life,” Academician Ovchinnikov points out. “I work in a field which presupposes the experimental approach to any organism, whether a microorganism, laboratory animal or human being.

“I am convinced that the highly complex problems of protecting the health and the very life of modern man cannot be resolved solely on the basis of theoretical concepts, general reflections or quackery. Such as finding an antidote to

ailments which we still often do not understand (or rather we understand a great deal but have not yet learned how to treat some of them effectively). We are talking about such dangerous diseases as cancer, serious nervous disorders, diseases of the endocrinal system and diseases of the brain. In these instances we are simply obliged to intervene, to experiment to find solutions to as yet unresolved questions.

“Laboratory animals have to be sacrificed so as not to harm man. But no matter how dramatic this may sound, they die for the benefit of people.

“Of course, the life of laboratory animals is not a simple or abstract question for researchers. For them these animals, all professional habits notwithstanding, are more than ‘research material’. There even are scientists who refuse to conduct biological experiments because their methods involve cruelty to animals. But there is really no other way of saving human lives.

“I believe that science will follow this road, and nothing will stop it here, because the results that have been obtained along this road are highly humanistic. We have already licked small-pox. Tuberculosis has ceased being a problem. We are close to eliminating many viral diseases. These are major achievements. Would they have been possible without experiments on animals?

“I can well understand a very solicitous attitude toward life in general. Because we indeed inject profound content into this concept. If someone forms the impression that biologists warp, deform or discredit this lofty notion when they say that life can be ‘destroyed’, ‘created’ or ‘constructed’ in a purely physiological or biolog-

ical sense, this is an imprecise understanding of what is actually happening.

“The realisation of what life is, the materialist explanation for the magnificent phenomenon, the loftiest of what the world around us can give and what we can imagine – this is the centrepiece of science. Coming to know the diversity of life and penetrating its secrets, we sense the unusual power of nature. And at the same time we feel the might of human reason, which is capable of comprehending this most complex and wonderful phenomenon and have a positive impact on it. This feeling imparts to man fresh strength, is a catalyst to progress. That is why I am in favour of an active attitude towards life.”

*Question 2. There is a limit which cannot be crossed in scientific experimentation. It is human life. Scientists, however, often obviate this ban. A medic (but this can be a researcher in any other field) does an experiment on himself and obtains findings very valuable for treating people, but dies in the process. And we call this a feat. It's his own matter, so one would think. On the other hand, however, he creates a precedent, showing that a human life can theoretically be risked in a dangerous experiment. Can he dispose of a human life, even if it is his own?*

Academician Ovchinnikov does not agree with the way the question is put:

“I believe that what we are talking about here should be precisely about heroism. The finest and loftiest human qualities – love of others and hatred of their pain and suffering – are the motivating factors for these researchers. It is easy to judge from the sidelines. But not everyone has their courage, conscience and sense of responsi-



bility. I, too, cannot help respecting such people. Today, however, an individual case does not solve problems. The world of modern medicine is the world of statistics. And until we, following the Russian saying, measure something seven times, we do not have the moral right to 'cut it off'."

In actuality, one measures not seven but millions of times. And until there is absolute certainty as to the value and safety of a drug it is not put into clinical use. In this sense Soviet medicine is, in the good sense of the word, more conservative than the health care systems in many other states. It is this quality of the Soviet health care system that is assessed positively in world medicine, specifically in the World Health Organisation.

Before asking Academician Ovchinnikov the next question, I want to point out the following as an aside. "It is heroism," he says about scientists who subject themselves to dangerous experiments. But it is in all spheres of life, not only in science, that such instances in our "sober age" are frequently called into question.

A person dies trying to save collective farm equipment from a fire. Right away there appear sceptics who query: "Is it worth it to risk one's life for some pieces of metal?" Another person sacrifices his life in a scientific experiment to save thousands of other lives. And immediately the question arises: "Does one have the right to dispose of a human life, even if it is one's own?"

Are such arguments fair? They are. No piece of equipment, even the most expensive, is worth one human life. No extremely valuable findings justify the desire to risk a life for their sake. This

concept of the value of human life is built into the moral bedrock of any labour, scholarly or research group in the Soviet state. Such is society's attitude to the life of any of its members. There can be no differing opinions on this score.

However, there is still the attitude of the individual to his social duty. There are situations when a person, by virtue of his or her inner convictions and moral principles, cannot act otherwise. And for them the question of danger cannot be the overriding one. To defend their principled stand at risk to their tranquility and well-being, or to risk their lives in a dangerous experiment is a phenomenon of a single moral order. Even though the situations, of course, are unequal for you and me. In his article "Hamlet and Don Quixote" the eminent 19th century Russian writer Ivan Turgenev wrote: "If a man who is about to sacrifice himself were first to figure out and weigh all the consequences and the entire probability of the benefit of his action, it is unlikely that he is capable of self-sacrifice."<sup>1</sup>

Defending one's views is commendable in and of itself. Such a stand, of course, can also be taken by stubborn fanatics standing up for obviously obsolete conceptions and viewpoints. Nevertheless, new views, too, are established in science precisely through such a position, by the characters of people who are courageous and persistent and are capable of self-sacrifice.

*Question 3. At one time it was considered im-*

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<sup>1</sup> I. S. Turgenev, *Collected Works and Letters* in 30 volumes, Vol. 5, Moscow, 1980, p. 335 (in Russian).

*moral for medics to use corpses for experimentation. As science developed, many of these bans were repealed and the individual and humanity were rid of absurd "moral" norms. Are there certain bounds here, eternal moral principles which a person should never violate? Or perhaps all such principles are relative, and society, in order to function normally creates moral bans, but their nature changes with the development of society.*

"I cannot, of course, speak out," Academician Ovchinnikov notes, "either for my contemporaries or, especially so, for those who will be living in the generations to come, and what I will say will only be my personal opinion. I am of the conviction that there are moral bounds which a person does not have the right to transgress either now or in the future.

"Mankind has traversed a path of many centuries. Today you and I are witnessing the triumph of socialism and the successful building of a communist society in the Soviet Union and the establishment of norms and principles of communist morality. Morality is class-oriented. And it changes in step with the march of history. However, people have lived by a whole series of fundamental moral norms throughout the ages and social formations.

"Reading, for instance, works of Ancient Greek authors, we very frequently come across explanations of human actions which satisfy us ethically. In general, some principles which should predominate in human society, on the planet Earth, should be constant and timeless. Such principles being vigorously established in the Soviet state today as the peaceful life of man and the improvement of his well-being, his cul-

tural development, the communion of peoples, the negation of racial and national discrimination and ségregation—all these are questions not only of the present day.

“We consider them to be a constant for humanity. If you will, these are questions of social Morality. I am of the conviction that, as far as the development of science, the conduct of specific experiments, their purpose and interpretation, and the utilisation of scientific breakthroughs are concerned, man must follow this Morality, whose essence can be capsulised as follows: for man’s benefit and progress. And it is not all that hard to formulate what is being done in science today for good and what is being done for evil.

“The timeless desire of people for peace is becoming especially topical today among the eternal principles. This question touches upon the conscience of literally every inhabitant of the planet. But that of the scientist to an even greater degree. Why is this so?

“You and I are talking about life, in its individual manifestation, so to speak. We are discussing whether we have the right to experiment on the life of an individual dolphin, rabbit or dog. We consider this question an important one, and rightly so. Yet a threat now hangs over life in the universal sense—over the entire biosphere with all its animals and plants, over all its flowers, forests and wildlife on land and in the sea, and over the pinnacle of organic life—man.

“Some people ‘console’ themselves and others, claiming that things have always been this way. That scientific and technological breakthroughs have always turned out either for

man's benefit or his undoing, for creative purposes or destructive ones. There have always been two cups to the scales, so they contend. But this complacency is immoral and even criminal, for scientists know better than anyone else, as the President of the USSR Academy of Sciences Anatoly Petrovich Alexandrov pointed out in a speech at the 26th Congress of the Communist Party of the Soviet Union, that there are no cups on today's scales, no alternatives to peaceful development. On the other 'cup' there are insanity, the senseless squandering of natural resources and man's talents and energies, and the danger of global self-destruction.

"Hiroshima has become a symbol of colossal loss of life. Yet the yield of present-day mass destruction devices staggers the imagination.

"Science's progress in unlocking the secrets of matter has now reached the point where it is extremely dangerous for the globe as a whole to gear fresh discoveries to military aims. On the other hand, if this very same factor is made to work exclusively for peaceful development, it could provide all people with food, lick serious diseases and resolve many other problems.

"I repeat: there is no alternative to peace. Whereas yesterday one could justify the need for it by appealing to the humane principles in man and humanity, today this argument is supplemented by convincing data of different sciences, the natural and technical as well as social. And it is on the scientists' shoulders that the tremendous moral responsibility falls of making these data known to millions of people, of impressing upon mankind both the terrible danger hanging over the world and the real possibility, and even

the necessity of forestalling disaster.

"It is this strictly scientific analysis of present-day reality that forms the bedrock of the Peace Programme for the 1980s proclaimed at the 26th Congress of the CPSU. It is a very realistic programme. The time that has elapsed since the Congress has witnessed a wealth of concrete peace initiatives set forth by the Soviet Government. But this is also a highly moral programme!"

*Question 4. How do scientists' conceptions of the social and civic meaning of their work influence the solution of concrete moral problems?*

"Public spirit today is a very important factor in the making of a researcher and in scientific development in general. Science is civic in the sense that a researcher always creates on a specific social soil.

"The view is sometimes expressed that the scientist enjoys some special 'right to extraterritoriality' and is not obliged to take account of the specific social tasks and problems of the state in which he lives. But this is not the case! Lenin's words 'One cannot live in society and be free from society'<sup>1</sup> fully apply to the scientist.

"This does not run at all counter to the belief that science should be internationalist, that the international scientific community should consolidate. However, when a scientist sets before himself a concrete research task he should have a clear understanding of the conditions in which it will be tackled and of his country's problems and concerns.

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<sup>1</sup> V. I. Lenin, *Collected Works*, Vol. 10, Progress Publishers, Moscow, 1978, p. 48.

“For scientists in the Soviet Union and other countries of the socialist community this question is obvious. There is more than patriotism at work here. There is also the scientist’s realisation of his own duty based on a specific world view.

“It is difficult to work in science today without an understanding of the materialistic underpinnings of any research project and without the dialectical method.

“A scientist should be more than a person who follows a specific path and plans his work in connection with it. He should have a clear conception of the problems of world views in his day and age. Without this criterion any definition of what is true and what is false, what is ethical and what is unethical, loses all meaning”.

*Question 5. Once I came across the question: is truth moral and is morality truthful? Isn’t this splitting of truth and morality symptomatic? Doesn’t the soberness of science lower the heights of moral criteria?*

“The search for truth is not an abstract concept. It is always the purpose, content and import of your work. The goal for which the search is being carried out is always important. And this inevitably incorporates elements of morality.”

Academician Ovchinnikov does not recognise science as wholly being a pure, abstract search for “something in general”. The search, then, is senseless, he believes. “You can lose yourself in the world of knowledge if you do not know what you are looking for. And when a scientist tackles a specific project, he unwittingly sets the boundaries of the investigation as well. Because he wants not only to separate himself from

extraneous knowledge but also to find the direct, rational path to his goal.

"One can, of course, pose questions on the cognition of truth in the most general and abstract form and not set oneself limits in doing so. But we do not do that! For any serious researcher, moral aspects proceed from his actual work, his world view, from the social problems important to himself and others which he is tackling through the medium of science. And why should the 'sobriety' of science and a more adequate approach to truth lower the level of morality?

"The search for truth should also be for man's benefit. It must be conceptualised. And if these conditions are observed, it will never force the scientist to counterpoise morality and truth or lead to a loss of the individual's moral foundations."

Academician Ovchinnikov's answer reminded me of a doctor friend's reflection on the kindness of the surgeon's scalpel. This was stated incorrectly in the literal sense. A scalpel cannot be good or evil. Only the person holding it can be good or evil. Yet the essence here of what a scalpel is used for has been perceived exactly! The person taking it into his hands is obliged to be kind and sensitive, he is obliged to intervene in the life of the organism in such a way as to harm as little as possible of live, healthy tissue while removing the diseased tissue. It is the same with truth. In and of itself truth cannot be "moral" or "amoral". Yet the researcher who is searching for it and operating with it cannot simply be an indifferent assistant. For in his hands he holds the *scalpel of kindness*.



Arches not there the sky above us?  
Lives not beneath us, firm, the earth?  
And rise not, on us shining,  
Friendly, the everlasting stars?  
Look I not, eye to eye, on thee,  
And feel'st not, thronging  
To head and heart, the force,  
Still weaving its eternal secret,  
Invisible, visible, around thy life?

Goethe. *Faust*



## DIFFICULT STARS

When daybreak came, the train was already on Armenian soil. I stepped out into the corridor. After the sultry night I let my face be washed by the wind. Foothills rolled by the window towards the horizon – yellow-green waves of land, scorched grass, and the ever-present chips of sharp precipices. Everything was covered by them. A woman standing next to me was looking into the distance. She said: “They are our rocks.” She said it lovingly, for it was her homeland. But also with bitterness, for it was a difficult land, where man had to grapple with the rocks, foot by foot, to clear away a bit of fertile soil.

Her words stuck in my memory the rest of the trip to Byurakan, where I was to meet with the director of the astrophysical observatory there, Academician Victor Ambartsumian. Could he, a world-famous scientist, twice Hero of Socialist Labour, member of the Presidium of the USSR Academy of Sciences, President of the Armenian Academy of Sciences and a member of dozens of world academies, also with sorrow and love, talk about his life’s work: “Our stars”?

There is a poetic astronomy in the world. The astronomy of Camille Flammarion, the ancient legends of the constellations, the former lode-

stars for the explorers Columbus, Magellan and Bering. And there is modern astrophysics. It is based on modern mathematics and uses the latest equipment for observing and registering the heavens. For this, the youngest and a rapidly developing branch of the ancient science of astronomy, the Universe is a vast physical laboratory where substance, field and energy are presented in every conceivable and inconceivable shape and state: from low-density interstellar space, where there is but one hydrogen atom per cubic centimetre, to pulsars, where there are millions of tonnes of mass per the same volume; from cold close to absolute zero to heat measured in the thousands of millions of degrees; from the incinerating energy of the Sun to the energy of explosions of supernovae, when they give off as much energy in a few days as the Sun does in hundreds of millions of years.

Such is the world in which this man lives and works. It is an uncommon turbulent world where thermonuclear reactions came to be studied earlier than in terrestrial laboratories.

Outside the window of his office in Byurakan is a fine orchard, in which apples thump onto the grass.

There is a sort of triptych on the wall. To the left hangs a colourful reproduction of an ancient manuscript. To the right is a large ivory-coloured sheet of paper with small black dots and spirals of galaxies, nebulae and stars. A photograph hangs in the centre. A typical face of an early 20th century Russian scientist.

“Your teacher?”

“Yes. Academician Aristarkh Belopolsky. A person whom I’ll never stop admiring. Especially

his well-nigh legendary devotion to science. He could spend all night observing the stars, and then, take a Sun spectrum the next morning, when the others have gone to sleep. There wasn't a single new star which erupted in his lifetime that he didn't investigate thoroughly."

Ambartsumian was sitting in an armchair, his arms on the arm-rests. He has thick eyebrows and a high forehead trimmed by thin ashen hair. His cheeks are lined with sharp vertical wrinkles. The handsome, youngish pursed lips are like a small taut bow. His brown eyes behind spectacles are tranquil.

What does time cost? For people like Ambartsumian it is a very expensive commodity. His time is compressed like the specific weight of some fantastic metal, the most valuable in the Universe.

It is not only on the launching pads of cosmodromes that people build bridges to the stars. Those bridges may also start where the mirrors of telescopes catch starlight and transmit it to sensitive instruments. Byurakan is one of the bridges built by man to outer space.

The research projects of the Byurakan astrophysicists are widely known, and it would probably take the rest of this chapter just to enumerate them. But what is interesting is to know which hours in his life Academician Ambartsumian considers to be pinnacles. Of his many projects which are a bright chapter in the annals of science, Ambartsumian singles out two. The *Great Soviet Encyclopedia* describes them as follows:

"In 1947 he discovered and investigated dynamically unstable, decaying stellar systems of a

new type, which he termed stellar associations. The extreme youth of stellar associations established by Ambartsumian made it possible to solve some fundamental problems of stellar cosmogony. He established the cosmogonic activity of central clusters – nuclei of galaxies responsible for such grandiose nonstationary phenomena as colossal explosions, ejections of huge masses of materials, quiescent outflow of matter, and high-power radio-frequency emissions.”<sup>1</sup>

This is what he himself says:

“In 1947 the celebrations for the 30th anniversary of the October Revolution were under way. Preparations were in progress for a special session of the USSR Academy of Sciences. I had received a call from Sergei Ivanovich Vavilov, President of the Academy at the time, who suggested that I deliver a report on new discoveries in astronomy. I had long been interested in the peculiarities of a number of star clusters and groupings. The strange thing was that these were not simple groups of stars visible to the naked eye or through a telescope. They were grouped according to a different principle. When stars were divided up into spectral classes, it turned out that hot stars of certain classes were concentrated on small sectors of the heavens.

“I decided to make these groupings the theme of my speech at the special session. I devoted the remaining months prior to the session completely to this research. As a result, it was at this session of the Academy that mention was first

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<sup>1</sup> *Great Soviet Encyclopedia*, Vol. 1, Macmillan, Inc., New York, Collier Macmillan Publishers, London, 1973, p. 328.

made of stellar associations as star-formation centres. The first step had been made in understanding their nature.

"My second pinnacle was in 1955. I was studying several non-stationary phenomena in galaxies at the time, and it gradually became clear to me that galaxies' nuclei play an important role in their development. This role had been ignored in the past. Nor was this new concept accepted by the scientific community right away."

Although a number of the hypotheses which had formerly been advanced by the Byurakan school and appeared initially to have debunked fundamental principles were no longer considered to be the bedrock of astrophysics, controversy still rages around Ambartsumian's hypothesis on the formation of stellar systems from original, very dense clusters of matter called "protostars". Many schools of astronomy, both in the USSR and in other countries, espouse a different viewpoint, namely, that matter initially exists in a rarefied state and then condensates into clusters of stars. The observational data at hand are still insufficient for conclusively favouring one of the two antipodes.

A mild-mannered and well-wishing man in conversation and in dealing with the people around him, Ambartsumian won recognition in the scientific community as an irreconcilable revolutionary, a scientist who jumped into the thick of things, who was endlessly polemicising with colleagues from other research centres. This perhaps more than the other factors united the young and old scientists into a fraternity of sorts at Byurakan. "Old" perhaps is ill-advised here,

as stars and galaxies are being studied by a team of very young scientists, and their positions and conceptions are at the forefront of science.

Next to the observatory, on the southern slope of Mt. Aragats, lives an extremely interesting Armenian painter, O. M. Zardarian. Naturally, his being a neighbour of the astrophysicists is mirrored in his canvases. Moreover, the artist strives to learn the spirit of today's research rather than formulas.

One of the subjects was prompted by an international astronomy symposium (many have been held in Byurakan) and is devoted to the interconnection between the teacher and pupil in science. In the centre a small circle of patriarchs, garbed in academics' gowns and caps, are engaged in a debate. It is girded by another, larger circle – the new generation. The latter are listening with deference to the teachers but are ready to take part in their debates themselves. The young men follow the teachers, but will ultimately take their place in the inner circle...

*Question 6. What do you think about the generation gap in science?*

"I would not like to see teacher-pupil interrelations being considered a priority problem," Academician Ambartsumian replies. "But I am also far from believing that there does not exist a problem of teachers and pupils, fathers and sons, in all spheres of life, including science.

"This, incidentally, is not an internal, 'family' question. It is in the family that fathers and sons normally love one another, and even then it is not always a bed of roses. In the broader sense this is a dialectical problem, where the change of generations and the conflict between new and



old intertwine. It is not all that simple here. A very old man can be an innovator at times, and a young person, a conservative. However, historically, innovation in science is usually the realm of the young. The new enters into conflict with the old. Through the development of this conflict, through revolutions in science and technology man gets a firmer grip on nature and broadens his knowledge about the world. Such revolutions naturally lead precisely to a dramatic change in views on the world around us.

“The pupil should nurture in his character and research style the kernel out of which an innovative spirit grows. Science does not need barren flowers, even if they are young.”

Ambartsumian's view is corroborated by the experience of the Byurakan Observatory. A case in point is the project conducted by two young astronomers, Tigran Magakian and Armen Gulbudagian. The observatory library has a copy of the Palomar Observatory Sky Atlas (named after the Mt. Palomar Observatory in the United States). It is the most complete astronomical atlas to date. Studying the heavens from it is just the same as observing them in their natural state.

According to our everyday notions, in order to discover a new star or comet it is absolutely necessary to look at the heavens through the lens of a telescope. But how far astrophysics is from such conceptions! Telescopes are focused automatically to the requisite sector of the sky and stars are also photographed automatically. The time of discoveries comes later, when researchers lean over the photographs obtained and revert to them many times. Thus, discoveries in astronomy are often wrought today by a careful

analysis not only of new photographs but also of old ones collected in atlases.

Drawing on the Palomar atlas, these two young people made an "inventory" of the weaker comet nebulae. And they discovered several dozen new bodies.

It was then that the 2.6 metre telescope was being commissioned, and Ambartsumian was in the process of selecting interesting objects for shooting. They were asked to give two or three of their nebulae. The atlas was brought over to him. There was a strange picture in it. A small star and a tiny segment of light next to it. A light fan usually opens up next to the star where there is a comet nebula. But it was different in this case. Ambartsumian was surprised: "What's so interesting about this. I don't understand. There is no nebula here." But they heatedly tried to convince him that there was! He gave in to their doggedness and later spent the whole evening upbraiding himself for their having "broken" him. But nothing will come of it, he thought. They are only wasting film...

When the pictures were developed, however, they showed something fantastic! A magnificent fan had broken away from the star. Why have they seen it, and he hadn't? "Perhaps," Academician Ambartsumian reflects, "the fact was that they had studied such objects so often and so thoroughly, atypical objects, too, that they had already developed the skill of looking with a specific purpose. So they were able to delve more deeply into this matter than I was."

The teacher's role in science is rather unique. He must help the pupil grow the "kernel of innovation" in himself. And this sometimes ends

with the debunking of scientific conceptions of the teacher himself. Nevertheless, the teacher's moral and civic duty, honour as a scientist and propriety as a human being (Ambartsumian believes they are indivisible) impel him to act precisely in this way.

A teacher's attitude to the "kernel of innovation" in a pupil is the touchstone on which the former's moral staunchness is tested. The teacher must become an ascetic. But the pupil must become an ascetic as well. Given the conflict at issue, devotion to science and faithfulness to scientific truth under any circumstances ensure unity among the different generations of researchers.

"This unity," says Academician Ambartsumian, "is typical, for example, of the Russian school of mathematics. Alexei Lyapunov considered himself a pupil of Pafnuty Chebyshev, and always emphasised this point. But these were very different scholars. Neither of them surmised that pupillage solely meant blindly following one's teacher.

"I naturally know the Byurakan group of scientists better than others. It provided many fine examples of the blending of different generations. The stellar spectroscopy laboratory, for example, was long headed by Eduard Yeremovich Khachikian (in September 1980 he was appointed dean of the physics department at Yerevan University, but is still active in the laboratory's work). Different generations of researchers here work very well together. There do exist conflicts, arguments and disagreements. But the priority here is a strong collective effort and a vested interest in the end results.

“The researchers here are engaged in truly interesting work connected with the existence of dual and multiple nuclei in galaxies and the extent to which this phenomenon is a consequence of galaxies’ activity. Everyone – the head, the researcher preparing a thesis on this topic (A. Petrosian), and other associates – are so involved in the project that the question of in what hierarchical order teachers and pupils should progress does not even come up.”

*Question 7. Today one can theoretically conceive of a scientist (say, a “pure” mathematician) living on the North Pole, regularly being kept supplied with all the latest findings, and moving his science forward. But in practice this does not even happen in fields where research does not directly hinge on a powerful experimental base or on industrial needs. For some reason science talents mushroom where the appropriate scientific and human climate exists. What is the role played by the moral climate of a research team in accelerating scientific and technological progress? How are the strength of a research group and the brilliance of the people who comprise it interrelated?*

“One can answer this question quite simply,” Academician Ambartsumian contends. “The moral climate, or morale, in a research or any other collective for that matter influences the end results. If the climate is unhealthy, the time and energy (not to mention the stress involved) of people which are wasted on squabbling have to be ‘subtracted’ from the project, from the final results. On the other hand, a good psychological atmosphere accelerates the scientific search process. All this is clear to the layman. I feel, however, that the question has a more pro-

found meaning as well.

“What is science? It is the production of fresh knowledge, the search for truth and the separating of its pure metal from the huge volume of the waste-rock of delusions or incorrect or outdated notions. Sometimes it is not all that easy for a researcher to reject views which he swore by for decades, which have become well-nigh a part of him but have now been disproved by the latest findings.

“Of course, truth by itself does not contain a moral principle. But man’s efforts to get at the truth are permeated by this moral principle; they constantly place the researcher in situations involving a moral choice. The choice of the instrument, the means with which the truth is reached (in the given instance we are not talking about telescopes or experimental units), the choice of weapon with which it is defended, the conditions and methods of scientific polemics—all this applies directly both to ethical demands and to moral conflicts in science.

“This should be underscored, for the emphasis is often being placed of late solely on moral or immoral use of already attained truths, and this emphasis is extremely important, but not the only one. And it is here that an indispensable role is played by the moral climate of a research team, that gravitational field which is called upon to maintain stringent moral demands of the individual and does not allow them to become empty, lofty-sounding phrases, but keeps them rooted in everyday reality.

“One person cannot always meet the great demands of truth. It is the collective who gives him wings in this aspect. One should not think,

however, that these wings are given to him from the side. Without a certain (and rather high!) moral level of the individuals comprising the collective the requisite general moral climate will not exist. These are highly interrelated factors.

“The Byurakan Observatory, for example, is always in the focus of heated scientific debates. Time has born out the veracity of some of the ideas of the Byurakan school, altered others and debunked still others. In any event, Byurakan has never been a peaceful backwater. From the standpoint of the events unfolding in our science, it is more evocative of a city under siege. And this, of course, makes higher moral demands on its defenders and unites them. Anyone who wants an easy time of it won’t last long in our city.

Underlying these words of Academician Ambartsumian’s is a position which unites the like-minded people on the observatory staff. It is not fortuitous that the very word “Byurakan” is so attractive to young scientists.

One of the paradoxes of Byurakan is the fairy-tale paradise and the certain asceticism there as regards matters not pertaining to work. But this asceticism is compensated for by the fact that here lives a staff of people truly taken with science. This deep involvement sometimes even takes on rather unexpected forms.

Elma Surenovna Parsamian, an associate of the Department of Stars and Nebulae, is known for her works in astrophysics. During one of her vacations, however, she took part in archeological excavations, and discovered the oldest observatory in Armenia. And there are many people like her in Armenia. A wide gamut of interests

and a tolerant attitude toward this gamut is an important condition in the formation of the moral potential of a school of science.

This, Ambartsumian feels, also applies to the so-called caprices and whims of talented people.

“If a person produces top-quality results on the job, others should at times put up with some of his shortcomings and peculiarities. There is something absolute aside from the barometer of our now ‘rising’ and now ‘dropping’ opinions and evaluations. This is devotion to science and work productivity and efficiency. I consider them to be the foundation of any research staff and any scientific school.

“The role played by the moral climate in science, which is progressing chiefly through the efforts of entire staffs, is greater now than ever before. Scientific communication and its very atmosphere are prerequisites enabling people to come to know the laws governing the world around them more correctly, rationally and speedily. All that is important is that intensive interchange and debate not develop into worsened job and personal relations. This depends not only on characters but also on the optimal sizes of staffs. I consider 100 to 200 people to be the optimal size. The Byurakan Observatory corresponds to this. Otherwise human intercourse becomes too unwieldy. A research staff is very informal from this standpoint. For it there exists a certain critical mass when people still infect each other with ideas. If, however, this mass is exceeded, the staff becomes unsteady, unmanageable and susceptible to all kinds of free-wheeling processes and the possibilities for moral ‘self-regulation’ become fewer and fewer.

“Yes, there should be an energetic exchange of views in science. If ideas are intensively thrashed out and tossed around, this is truly science in action, which ultimately leads to major results.

“This is why the lone researcher on the North Pole will have a hard time of it. Only a genius might stand it. But the age of geniuses in the classic sense of the word is over. What lay on the surface and what could have been raised up singly (I don’t claim that this is easy, at times it required Herculean efforts) has already been raised. Today the time has come for planned in-depth development. And this is more convenient to do together.

“As to individuals in a collective, naturally, the brighter its members, the stronger it is itself. It’s harder working with bright people. But, when you come down to it, that’s the way it should be with a fine staff—mutual infection with ideas and mutual reflection of ideas.

“Aside from the strength of a staff depending on the brilliance of the individuals comprising it, what is also important is the interaction between the significance of a scientific problem and the significance of the individuals who attempt to solve it...”

Academician Ambartsumian showed me a thick volume in a dark blue cover he had received from New York. It was about balance figures of heavenly bodies and design ramification problems. It is mentioned in the foreword that the contents of this book is connected with three great names—Poincaré, Lyapunov and Andronov.

“These are truly great names,” Ambartsumian said. “It is of note that two of them, the mathe-



matician Lyapunov and physicist Andronov, are Russian scientists. As you can see, an important problem can unite very big celebrities who don't necessarily live in one part of the world and even at one time.

"It is a wonderful and noble feeling to realise that you are a member of a great community embracing the whole world—a global family of researchers! One can, of course, also realise this singly on the North Pole. I am convinced, however, that when you've divorced yourself from people you can't advance science in present-day conditions."

*Question 8. The finest scientific schools are very viable. It usually takes longer than one lifetime to solve an important research problem, and, if the baton is not passed to able hands, a serious scientist cheapens the import of his life. However, how does one hand down from one generation to another the moral as well as intellectual potential of science?*

Ambartsumian mulled the question over for a while and replied:

"To hand down moral potential the teacher should simply be a decent person in all respects. But objections may be raised here, to the effect that the personality of a young researcher is formed under the influence of many factors, and the teacher's example alone (do as I do) is often insufficient. This is a reasonable objection. Therefore, aside from the personal example of the older generation, a specific system of moral criteria, requirements and ideals, a system of introducing young people to these criteria and ideals, should be implemented, supported and constantly reproduced in a research team (under

the influence of its senior workers and through the efforts of management and public organisations). I want to emphasise that this is not a 'system in general', but one crystallised precisely from the conditions and traditions of a specific laboratory, institute or scientific school.

"We are sometimes apprehensive of a systemic, organised approach to such 'subtle matters' as morality. And generally not without good cause. The approach here should indeed be sensitive and informal. It is indeed a very fine line between tolerance of people's idiosyncrasies and respect for the uniqueness and independence of the human personality, on the one hand, and intolerance of violations of moral norms and traditions, on the other. Nevertheless, when by virtue of its 'fineness', individuality and informality this question finds itself beyond the bounds of the group's attention, we sustain moral losses.

"Giving a specific answer to the question at hand (it in itself is a highly complicated one which for the time being cannot be answered simply; we shall consider that my opinion is only one possible way of looking at the problem), I would name several conditions which I feel should be met to ensure the handing down of moral potential in science and scientific schools.

"Firstly, a research staff should be engaged in problems which are vital for the progress of society and for science itself and get at the burning issues in their field. An innovative spirit, the absence of the deification of solutions in the past, selfless search and the necessity to risk are a fine antidote to moral stagnation.

"Secondly, a head researcher of any rank is himself supposed to provide an example of a

lofty moral attitude toward work, people and life not in word but in deed. It is good if this comes about involuntarily, if he does not have to think about it but simply remains himself. This is not always the case, however. More often than not he has to control himself, take specific efforts and look at himself closely from the sidelines. This analysis from the sidelines is essential, as a head researcher determines more than anyone else the moral climate in such an informal collective as a scientific one. Sometimes the mood of many staffers can be affected by one word of irritation blurted out. Contact with a head researcher should always be a moral lesson. But in no instance should it be an importunate lesson.

“Thirdly, the system of socio-political education which is effected in the life of any research team includes concern for the moral climate. Naturally, I’m talking not about a set of formal measures, but precisely about close, everyday attention to morals. The moral climate is, I think, something imperceptible, something which cannot be concretised in formal reports. Nevertheless, it requires constant efforts if it is to be reproduced. It is like air. We cannot see or touch it, but we immediately sense when it is missing. In any event, public opinion reacts rather sensitively to it in any work group.

“Each of these conditions is essential, but not sufficient. They become essential and sufficient when they are fused.

“The intellectual and moral baton is indeed passed on particularly intensively and fruitfully in scientific schools, for this is the handing over of the baton from one individual to another.

However, research schools are formed not only and not so much for the sake of continuing the life's work of the older generation (which is absolutely just), but first and foremost for the sake of establishing new elements in science through young people. Owing to the fact that many research groups in the Soviet Union exhibit such unity, we have many fine schools in mathematics, physics, biology, astronomy and other sciences."

I showed Academician Ambartsumian a letter in which his name is mentioned.

*Question 9. The Soviet writer Konstantin Paustovsky has a short story entitled "The Hunting Dogs", which is about how by sheer coincidence an astronomical observatory in Spain which had been far removed from everyday life became deeply involved in the civil war in that country. The contrast there is very pointed. But it is also true that the modern astrophysicist has to deal with characteristics of time and space and in general with notions which are sometimes incommensurate with our "everyday" conceptions. Academician Ambartsumian, for example, wrote in an article the word "recently". And he specified that he was referring to an event which had taken place several millions of years ago. Does the object and nature of research leave an imprint on the research team, on its moral aspect? How is the moral responsibility of a scientist engaged in fundamental long-term research to his contemporaries and their present-day needs manifested?*

Academician Ambartsumian replies:

"Over the centuries and in all fields of science there has existed a rather high sense of responsibility for results, both long- and short-term. We

sometimes picture the alchemist as some monk fenced off from the world by the walls of his cell-laboratory. Yet, he was engaged in a most 'applied' research, trying to obtain gold for some prince. And he answered for his experiments with his head. But today, of course, the degree of responsibility is very high. I feel it is particularly high in spheres dealing with fundamental research, where applied results are not always clear. Time periods here are more indefinite. Administrative responsibility is less obvious. Moral responsibility is what is more manifest. Greater hopes are pinned on the researcher's responsibility. However, even in applied research, where there must be very great responsibility for deadlines and the end result, nothing will come of it without moral responsibility.

"Nor should 'pure' research be presented as though everything progresses solely through people's consciences. Even in these areas there are other very strong catalysts, there is an unwritten competition among different institutions and scientific centres. Someone is the first to obtain new findings and thus spurs on the others... Moreover, the 'independence' of fundamental and 'pure' research of today's needs has become purely symbolic in many fields of science at present. Nowadays, in order to take a new practical step forward one frequently has to delve into fundamental principles of substances, energy, nature and society. The dramatically narrowing distance between discoveries and their practical use is one indirect indicator of this process.

"And whereas at some time in the past one could picture a researcher who could afford not

to think about his responsibility for his work to his contemporaries, today I can't imagine such a person. That is, he himself can harbour certain illusions on this score. But life normally impels him to be morally responsible to his contemporaries rather than his descendants.

"Look how quickly – literally during the lifetime of two generations – nuclear physics, which is supposedly geared to the most distant perspectives, more to the stars than to human needs, has turned into both a practical science and a sphere of the highest moral responsibility. How many moral upheavals it has caused numerous nuclear researchers who initially thought that they were engaged in 'pure' cognition far removed from the needs of their contemporaries!

"As to a special moral imprint on a staff doing fundamental research, like an applied research staff or any other work group, I personally do not see any 'elitism'. Especially when this refers to a research team in a socialist society, in the Soviet Union.

"We are all citizens. This means that we are responsible for our society and our state. And for this reason our observatory staff is not 'far removed from everyday reality', not to mention the fact that it carries out practical projects for the national economy.

"The country needs all types of working people – iron-and-steel workers, biologists, historians, cosmonauts, grain growers, astronomers, drivers, artists, etc. And in this sense I do not see a difference between production teams and research teams. Labour is our prime duty to society. And our duty has to be done honourably. For this reason the overriding task for all

of us today is to foster everywhere an honest, socialist attitude to work and as a result to raise productivity and quality.

"Of course, each type of work has its own specifics. For example, initially research work is not subject to norms. Today it is planned. However, not a single serious researcher will give you a guaranteed deadline or claim that some unresolved theoretical problem will be solved in time for a national holiday given the normal eight-hour working day. A researcher knows he's sure to lag behind and fail if he works eight hours a day and not the amount the project calls for."

It is in connection with this view on the meaning of research work that Victor Ambartsumian doesn't like the word "scientist" very much. He feels that this word contains an element of self-satisfaction. Others should call a person a scientist. Moreover, this is an exclusive and elevating title. Academician Ambartsumian recalls how a new associate came to him and said: "As a scientist I surmise..." Ambartsumian was amazed at his boldness. He has been working on scientific questions for more than half a century, but does not consider himself a scientist. He feels that if one has to introduce oneself, it is better to say "research worker", and if one wants to praise someone, "worker of science". Thus the stress is placed on the moral side, on labour itself.

The following lines by Pushkin prompted another topic in our conversation:

Like a lawless comet  
In a vast circle of heavenly bodies.<sup>1</sup>

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<sup>1</sup> A. S. Pushkin, *Collected Works* in ten volumes, Vol. 3, Leningrad, 1977, p. 66 (in Russian).

Mankind has always gazed up at that vast heavenly dome, the universal harmony of stars. For centuries we had no other perception of the luxuriant starry heavens than their slow revolving around the North Star and twinkling through the vacillating layers of the atmosphere. "Immobile stars" was the most common term. Comets were the exception. In the twentieth century science has discovered a different sky and different stars. We have learned the notions "expanding Universe", "white dwarfs", "pulsars" and "quasars". The heavens have ceased being immobile. However, no matter how the picture might have changed, it has never been just a cold abyss for man. From time immemorial man has been accustomed to comparing the world of stars and the Universe with the scope of his personality. "And is not the presence of the Universe invisibly clear around us?" These words were written long before the first space flights...

*Question 10. When Immanuel Kant wrote his famous "the starry heavens above me and the moral law within me", he meant by the former and latter something solid, which one could always draw on. Science has made deep inroads into the heavens. This is clear. But how do things stand with the "moral law within me"?*

Academician Ambartsumian leafed through envelopes of fresh mail and closely examined the stamp on one of them: Tsakhkadzor *khachkary* (stones with designs hewn by thirteenth century Armenian craftsmen). Then he returned to our conversation:

"Kant, as we all know was an idealist in his conception of morality and in his ethic theory. Is



it rightful to make direct comparisons with our present-day debates on knowledge and morality, which are, in any case, well rooted in reality? I think it is not. There are scholars who devoted years to studying Kant's philosophy. I am not one of them. For this reason I consider it incorrect to make judgments on what he meant by particular words. The tenet of Kant's adduced above is repeated rather frequently. However, at the present juncture it has in effect long lost its original, Kantian, meaning, and has taken on a wealth of modern interpretations. One of them is given by the author of the letter, who ascribes his own interpretation to Kant.

"However, while making this reservation, let us agree that if Kant were living in our day he would not have recognised the 'starry heavens above me'. In our present-day conceptions this is an endless boiling caldron where worlds scatter, explode and expand, and intensively interact with one another; where stars explode, giving off to space energy equivalent to thousands of millions of hydrogen bombs. These heavens have been given to us by modern astrophysics.

"Yes, everything is changeable today in the field of knowledge I work in. All the edifices of old notions are being torn down. Every day brings fresh proof of instability and feverish processes. We are becoming convinced of the extremely unsettled nature of the world of stars, galaxies and nebulae.

"As to morality, it, too, is not something petrified or fossilised that has been given to man from the distant past forever. It has always borne the imprint of the times in which people live, of their ideas and passions; it has always

been connected with their actual needs and interests. Its changes at different stages of history have reflected changes of socio-economic systems. The struggle of various moral views ultimately led to a conflict of interests of antagonistic classes. It is very important to stress this point if we are talking about modern interpretations of the 'moral law within me'. Nor have the so-called eternal moral precepts, for that matter, been given to man 'from above' or 'from the side'. They were evolved by man, experienced by him over the centuries, they were born from the real practice of many generations.

"Naturally, the higher the level of social development, the greater possibilities there are for actually establishing basic ethical precepts – this dream of people about honest, fraternal relations with one another. It is not fortuitous that for the Soviet people socialism and communism are connected with genuine humanism.

"I feel that those who adduce Kant's winged words very frequently mean a steady interest in the depths of the Universe and at the same time in the depths of man's inner world. They mean that which man focuses most on in the world about him. I share this interest in the heavens. Yet I also know many people who are attracted by a much wider range of the manifestation of natural life.

"I, too, am interested in many other things beside the starry heavens. I am astounded, for example, by the fact that we have penetrated the Universe rather deeply and thoroughly studied the surface of our planet, but we know virtually nothing about what is more than ten kilometres under our feet. You will agree that the realisa-

tion that you are treading on a 'mystery' is an amazing thing!

"If you think about it, the heavens and man's inner world are but two graphic illustrations of the baffling phenomena of the world we live in. There are others. For example, the history of any people and the culture of any nation are outstanding phenomena just as worthy of our interest as the starry heavens above us. All the more so since the family tree of each of us, people of the Earth, are pure and life-giving springs which can nourish the consciousness of modern man.

"Getting back to the stars, I agree that for centuries astronomy has been a peaceful science (with the exception that Kant was precisely one of the first 'disturbers of the peace' in it). This was the world of immobile stars. Of course, the comets which disturbed this quietude, produced a stunning impression in the times of the great nineteenth-century Russian poet Alexander Pushkin. Today we know that the immobility of the heavens is but an old decoration. But what a fine decoration!

"Incidentally, today, too, we see the skies just as they were seen by Ulug-Beg<sup>1</sup> and Pushkin. Modern poets with their modern knowledge about pulsars and galactical nuclei should see and feel as much as Pushkin when they gaze up at the stars. He wrote about a lawless comet in a vast circle of heavenly bodies, having in mind, however, above all a human being, a woman."

It is evening outside. The pink Armenian tufa which faces the towers of the Byurakan tele-

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<sup>1</sup> An Uzbek astronomer and mathematician (1394-1449).

scopes blends in with the twilight and its unsteady transparent light, when the white colour contrasts with the whole world, and the flesh-pink colour of the tufa harmonises with the dusk, with the quiet in which the voices of children and birds are particularly audible. The stone design which girds the telescope towers seems to emphasise the passing down of expertise: from the ancient art of stone-cutting to the modern art of catching the weakest starlight.

This interplay of the times is not fortuitous. Nor is it fortuitous that when you look at the towers of the Byurakan telescopes you call to mind the ancient fortresses and churches of Armenia. Standing by the walls of this not so old observatory you feel like thinking about the distant, centuries-old roots of science.

At the conclusion of the conversation I asked him about "our rocks" and "our stars".

"When people say 'our rocks'," Ambartsunian replied, "this brings to mind my childhood, my homeland, my people and their history. That which I cherish most in my heart. The stars which modern astrophysics studies are, when you come right down to it, something speculative. The modern astronomer does not spend all that time looking up at the sky during his working hours. Naturally, we are excited over each new photograph of the heavens. But this is incomparable to what our native land, our stones arouse in us. If we're referring to surmounting obstacles, there is another question that arises: which is harder—to study stars or to till the stones."

Half conscious of his frenzied, crazed unrest,  
The fairest stars from Heaven he requireth,  
From Earth the highest raptures and the best,  
And all the Near and Far that he desireth  
Fails to subdue the tumult of his breast.

Goethe. *Faust*



## WHAT DOES IT MEAN TO BE AN OPTIMIST?

The editors at *Izvestia* were discussing the plan for the New Year edition. They hit upon the idea of asking prominent people in the country—a worker, collective farmer, and scientist—to make a symbolic toast to the readers. Presently I am sitting in the flat of Academician Bonifaty Mikhailovich Kedrov. It is a cozy room, and soft music can be heard—the Paul Mauriat Orchestra playing “The Windmills of My Heart”. Following Kedrov’s suggestion (“It would be a good idea to learn what people want and are interested in before wishing them anything”) I picked up a few of the letters sent into the newspaper.

*Question 11. Academician Kedrov speaks about four major scientific breakthroughs in the 20th century: the harnessing of atomic energy, the appearance of self-controlled devices and the birth of cybernetics, space exploration, and the creation of modern genetics. What new breakthroughs can we expect from science before the century is out?*

“One’s thoughts,” replied Kedrov, “can travel ahead to the foreseeable and unforeseeable future, losing track of actual human possibilities and requirements. On the other hand, one can put one’s nose to the grindstone and not find a

minute to raise one's head and think about what is in store for one beyond the horizon. Clearly, the optimum variant will be a precisely pinpointed mean between the ideal and today's potentialities, between 'tomorrow' and 'today'. It is difficult to find this mean. It seems to me that this task is successfully solved in the documents of the 26th Congress of the CPSU, which combine plans for the 11th five-year plan period with an eye to the following decade.

"The first thing I single out for myself in the documents of the Party Congress is the hopes which they pin on the social, natural and technical sciences and their interaction in tackling the most important economic and social tasks. I'd like to talk about the role of the social sciences in particular. In the 20th century they have repeatedly proved their vital role in human progress, in correctly tackling man's problems. I feel that this role will be greatly enhanced at the end of the century, as the scientific approach will be increasingly affecting many different aspects of the life of Soviet society, which is building communism. It is for this reason that the cooperation of the social and natural sciences, buttressed by the technical sciences as the connecting link between them, will be established ever more solidly.

"Scientific breakthroughs developed logically, one from the other, and do so today, too. Proceeding from this belief, we can surmise that the further development of the scientific and technological revolution will affect man himself first and foremost. His biology, psychology and thinking.

"In 'restructuring' the environment and



enhancing his control over nature, man likewise changes the conditions of his existence. And, inasmuch as the scope and nature of these changes are becoming global in our day, there arises a need to look at man from the standpoint of his future biologically as well as socially. Our health, longevity and the capacity to preserve our biological activity amidst mounting psychological loads—all this makes it incumbent upon us to study issues which were not analysed thoroughly in the past, with an eye to the long term, when consequences affecting not only the next generation but our distant descendants are prognosticated. And the tackling of these problems inevitably brings biology to the forefront of scientific and technological progress, as this science determines a wide range of new aspects of the science-practice link.

“The Guidelines for the Economic and Social Development of the USSR for 1981-1985 and for the Period Ending in 1990 which were endorsed at the 26th Party Congress mention the following among the tasks placed before science: ‘understanding of the mechanism of physiological, biochemical, genetic and immunological processes of man’s life activity, improvement of the methods of prevention, diagnosis and treatment of the most widespread diseases, development of new medicines, preparations and medical equipment’.<sup>1</sup>

“As you can see, we are not talking solely

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<sup>1</sup> *Documents and Resolutions. The 26th Congress of the Communist Party of the Soviet Union, Moscow, February 23-March 3, 1981*, Novosti Press Agency Publishing House, Moscow, 1981, p. 176.

about exploring some new methods of treatment. What is at issue is the study of the very foundations of the vital processes taking place in the human body in connection with the conditions into which it has been placed by the entire course of the scientific and technological revolution, and also the ways the problem can be resolved in its entirety. This requires tremendous efforts on the part of Soviet scientists. No less efforts, I feel, than those expended in putting man into space.

“The shift of science’s focus to the human problem will give, and is already giving, other practical applications connected with the bioligisation and biochemisation of industry, the synthesis of biopolymers and the synthesis of foodstuffs, first for domestic animals and then for man.

“It is not only a matter of biochemistry and physiology, of course. How can man, who has been accustomed to a specific psychological rhythm for centuries, restructure his entire psyche? To what extent? And how advisable and necessary is this?

“Let’s presuppose it’s clear that in order to prevent a young school leaver from immediately falling hopelessly behind the times the volume of new information in the school curriculum has to be increased drastically. But how do you do this without overloading students and sending them off to colleges and universities already psychologically worn out?

“The telephone book can be used in different ways. One can, say, memorise all the numbers one after another. But isn’t it better to use the alphabet to quickly find the number you need?

Having adduced this simple but necessary example, let us examine the school and higher educational establishment from this vantage point. Today the finest 'fruits of education' are growing precisely in places where the person in the lecture hall or classroom is taught to acquire new knowledge by culling secondary information from what is all-important. If, however, we hold to the traditional view and endlessly stockpile volumes of information necessary for study, overloading both the memory and psyche of schoolchildren and students, we will inevitably arrive at study without rest. And, as you yourself understand, this is absurd.

"What can I personally suggest? This is the point—here we often confine ourselves to personal opinions and suggestions of individuals, although they may be based on vast experience and familiarisation with the problem at hand. What is needed is comprehensive research by psychologists, instructors, educators, physicians, sociologists, philosophers. Then their findings must be crystallised into recommendations necessarily followed by their practical implementation.

"Thus, psychology should become in the near future one of the leading branches of knowledge, not a speculative, meditative science, but a practical and effective one actively involved in the life of modern man."

*Question 12. If in the less than 20 years left till the end of the century scientists are concentrating directly on man, from his biology to his inner world, what then is the connection between this objective trend in science and the social environment, the organisation of society?*

"I am stressing all the time," says the scholar, "that we are talking above all about our socialist society, all the foundations of which rest on humanistic principles: everything for the people, everything for the complete development of the individual's potential, for the satisfaction of his material and inner needs in the interests of the whole of society.

"The objective shifting of science to the human problem coincides with our aspirations, programmes and plans. We are building the society of tomorrow. We are building it for the people who are to inherit from us all the fine things that we have managed to create for them. What kind of people will they be physically and morally?

"When this problem is researched, Soviet philosophical, political and social positions foster rather than hamper the pooling of the efforts of scientists from states with different social systems. It would be absurd, for instance, if in tackling such a global problem as environmental protection all of us, the people of the Earth, irrespective of our states' social systems, did not try to find a common platform for joint research geared to improving interaction between man and the environment."

*Question 13. I shall begin with three examples.*

*First. Attention has been focused today on the pedagogical legacy of Vassily Alexandrovich Sukhomlinsky. The point is to preserve, at least at the initial stages, the child's natural entry into today's complicated world.*

*Second. The famous paradox of Einstein, where he claimed that he owes his scientific achievements to having developed slowly but*

*naturally (no one accelerated his development).*

*Third. The great interest in the architectural design of the Lazdinai housing estate in Vilnius (its designers have been awarded the Lenin Prize). Though many new construction projects are original, they contrast too much with the natural environment. Lazdinai exhibits farsightedness and an attitude of care towards nature; it blends in with the environment.*

*Perhaps all these three examples are united by modern man's heightened interest in all that is natural—from the "natural" formation of the personality to the natural environment—as a counterbalance to the ubiquitous "chemistry" in our day?*

"This longing for the natural does exist, of course. But it is explained more by the fact that still far from all our artificial equivalents are able to compete with their natural prototypes in all indicators.

"Admittedly, when dealing with the natural, undetermined development of the human personality, you are talking about a special, very difficult problem. But when a forest and park are compared for instance...

"Who will say that the park created by botanists, ecologists and artists definitely has to be worse than the wild woods?

"Of course all of us are children of our times and are still mistrustful of all that is artificial. Let's say I was in Switzerland. I had gone up into the mountains. It was completely bleak all around. Suddenly I see signs. Cafe, left, hotel, right. If a person is tired and hungry he will be pleased to discover these things. But I feel somewhat disappointed inside.

"Just as it is impossible to treat as equal the

inner world of different people, so too is it impossible to inculcate in them an identical attitude toward the environment. Some will feel more natural in a fine park sprawled out next to their homes. Others will travel any distance to isolated areas, to thickets where man has yet to tread.

“Somebody might make a case for animals living free. And he would be right. But a person who keeps domestic animals is also correct in his own way. A house-kept dog—is this indeed natural environment? But contact with domestic animals fosters the formation of positive and humane traits of character in children and instills a sense of respect for nature in general (naturally, there is no absolute or direct dependence here).

“As to environmental protection, we are referring above all to protecting man with the aid of nature. For it is only in a healthy natural environment that man can develop both physically and spiritually. What is at issue should not be the ‘Back to nature!’ slogan but the use of nature in the form which best satisfies man himself.”

*Question 14. A situation has taken shape today where many scientists, especially in sciences connected with a great degree of abstracting from live hues, sounds and impressions, from the usual perception of the world by most people, exhibit to a certain extent an attitude of haughtiness toward the necessity to be understood by the broad masses. Some leading scientists do not have an inner need to be understood by laymen. There are sometimes serious reasons for this (fear of oversimplification, vulgarisation, etc.). But don't both society and science as a whole lose if elementary*

*understanding is destroyed between them?*

"Both 'introverted' science," replies Academician Kedrov, "and the public movement, if the latter is not backed by science, are impotent by themselves. I feel that the very phrasing of the question contains the answer as well. It is because both society and science lose when understanding between them is absent that it is extremely important to work for this mutual understanding, no matter how hard this task may seem, or how powerful the inertial forces are that have to be overcome.

"But here, too, advance should be reciprocal. A prominent scientist cannot stoop to oversimplification. And the broad masses of working people should elevate themselves to comprehend his ideas. After all, this country has universal secondary education.

"Wonderful ideas were set forth, for example, by Academician Vernadsky during the war.<sup>1</sup> The battlefield approached Stalingrad at the time, but he was working out a concept of how science should develop in the future. Unfortunately, only today is the public beginning to truly comprehend the farsightedness and profundity of his ideas (perhaps due to the recent heightened interest in ecological problems). His *Reflections of a Naturalist*, on the interconnection between dead and living nature and scientific thought as a global phenomenon, has been published and is enjoying popularity. He is a very interesting thinker. Very..."

*Question 15. What is the influence of the scien-*

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<sup>1</sup> The Great Patriotic War (1941–45) against Nazi Germany.

*tific and technological revolution on man's inner world? What are the most important consequences of this influence (both positive and negative)? In what direction will it be developing in the short and long term, and what should we do to make this direction a favourable one for the individual and humanity?*

"You see," Academician Kedrov points out, "much has been said and written now both about these consequences and the great possibilities which the scientific and technological revolution provides for man's intellectual enrichment. These are ecological questions, the problem of overloads which are plaguing man's psyche, and the very complex tasks of planning, forecasting and organising this entire process. I would, however, point out what applies directly to the influence wrought by scientific development on man's inner world. And perhaps I'd rather talk about what worries me and not what makes me glad. The former, after all, is more obvious.

"The scientific and technological revolution does not encompass the natural sciences and engineering alone. It is a historical process which cannot be understood if the interconnection is not revealed between its social and scientific aspects, between the development of science and engineering and the development of society and the human personality.

"The personality will be formed and will flourish if not only its rational and logical facets, but also its humanistic, emotional and artistic ones, are developed. Naturally, they must be developed within the context of new conditions. After all, it is not fortuitous that generally fine



traits of literary and not only literary heroes of the past are beginning to seem to us to be 'impractical' and 'idealistic'. It is for this reason that it is not always easy to find the bridge from them to these qualities,—tailored, however, to our times. The twentieth century has its Don Quixotes, Hamlets and Joans of Arc, too.

"Today it is hard to harmoniously develop the personality and neutralise the technocratic influences on it, influences of narrow pragmatism. On the other hand, if we do not enhance humanistic, ethical and aesthetic trends in the formation of the personality, the tremendous pressure being exerted on this formation by engineering and the science being implemented in it, as well as pure utilitarianism can eclipse and even stifle a person's interest in things intellectual. And then the vacuum will immediately be filled with such 'values', with such time-killers which give nothing either to mind or soul and standardise the personality and even destroy it.

"Man has always had, has and will have needs. But what is all-important is their nature, what values they are oriented to. I always recall in this connection a story read to me when I was a child. An old English seaman was asked what he would buy if he had a great deal of money. 'Rum and tobacco,' he replied. What else? Rum and tobacco. But what besides that? More rum and tobacco. But what if he buys all the rum and tobacco on earth and still has money left, what then? He thought for a long time, and then said: 'Even more rum and tobacco.'

"If we are going to talk about what we should do to make the influence of the scientific and technological revolution on man's inner world

more favourable, it is extremely important now to arouse and bolster requirements in people and turn them into a stable tradition, a habit, if you will. It is only by fully satisfying these needs that a person can assert himself as an individual who realises his responsibility both to society and to himself, and who does all in his power to preserve and augment the material and spiritual riches of his country. So that each individual should feel his personal responsibility for this.

“Of course, the scientific and technological revolution engenders a certain determinism of social life enabling a person to swim with the current of events. But this determinism does not remove a person’s responsibility as to what kind of man he is, what he is achieving in life and what he will achieve.

“Just recently I showed my daughters a passage from Lenin’s lecture ‘The State’, where he talks about independence: ‘Only when you learn to find your way about independently in this question may you consider yourself sufficiently confirmed in your convictions and able with sufficient success to defend them against anybody and at any time.’<sup>1</sup>

“What the socialist state needs is creative individuals capable of independently taking correct decisions and acting accordingly.

“Today the formation of the personality involves the overcoming of difficulties, the sometimes agonising search for answers to problems, and the independent solution of formidable tasks. You probably know this from your own

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<sup>1</sup> V. I. Lenin, *Collected Works*, Vol. 29, Progress Publishers, Moscow, 1977, p. 471.

experience. What school assignments generated the most interest, which ones do you remember to this day? The ones that were hard to solve, the ones which took a long time to work out. Those which are tackled easily frequently do not stick in our memory; they groom neither the mind nor the will. I once had to decipher a manuscript of Dmitry Mendeleyev.<sup>1</sup> We deciphered thousands of notes. But I particularly remember one of them. And it was by no means the most important. But we had worked hard on it for probably a year...

“Yes, the personal should blend with the public and, when necessary, be subordinated to it. But subordinated in such a way as not to suppress or stifle the personal.

“The development of individuality, of the personality, which naturally blends in with the collective and which sees the meaning of life to lie in selfless service to society, should begin in the schoolroom. And this task is a highly complex one requiring creative endeavour, it is devoid of hard and fast rules.”

*Question 16. It is often said that fluidity can get one bogged down. But doesn't much here depend on us ourselves? By demonstrating an ordinary rather than phenomenal will, one can assert oneself as an individual and offset stereotypes. See friends for a drink in the evening or go to a concert, or to the library—here a person has a free choice.*

“The power of ‘everyday stereotypes’ cannot

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<sup>1</sup> D. I. Mendeleyev (1834–1907), the Russian chemist who discovered the Periodic Table of the chemical elements, a versatile scientist, educator and public figure.

be rated too highly. It's quite easy to get someone out with the crowd. This is natural to a certain extent. If one declines to spend an evening with his usual circle of friends and decides to go to a concert, he sometimes has to go against the current. And one has to have not only will power, but also a very strong need, one bred and developed in the person.

"It is one thing when a person engaged in his basic work upgrades his knowledge and skills. But try independently to master the knowledge you need. Such as learning a foreign language without tutors or special courses... Many hope 'to begin, starting next Monday'. Only a handful actually do. Why this is so gives food for thought.

"Or take the following example. A crowd of young people gets together and spends the whole evenings wandering all over the city. Many people are already looking at them as practically potential hooligans, even though they're bothering no one, save for their excessively loud singing. But this is not the most alarming thing. They are idling around. They are forming a habit of killing time. And this habit is normally accompanied by an extinguishing of inner needs, which, in turn, can serve as the ground for a parasitical mentality, for irresponsibility and for anti-social behaviour.

"Free will in our day hinges largely on the inner wealth and ethical wholesomeness of the individual. The deeper and broader his spiritual needs, the freer he is in his choices and the less he depends on the stereotypes dictated by the scientific and technological revolution."

I said good-bye and went outside. Snowflakes

sparkled in the light of the lamp-posts. Like night butterflies converging on a light. People were walking past me and in my direction. It was a thick crowd on New Year's eve in the capital city. Going over our conversation in my mind, I thought that we talked not about some abstract responsibility of the individual but about responsibility to these specific people hurrying now from work, thronging on lines in shops, on platforms in the subway and at train terminals, and filling the halls of the Tretyakov Gallery and cinemas and libraries. To people with thousands of small and big worries, problems and joys, with their characters and habits, with their introverts and extroverts.

And I again reverted to the question of whether the scientist should seek a common language with all these people, with thousands and millions of their contemporaries, when they address them from the rostrums of big auditoriums, on the TV screen and in mass-circulation newspapers and magazines, or does he have the right to a high-flown scientific style.

If we are talking simply about equivalents of complicated things everyone can understand, should the scientist's valuable time be wasted? There are popular science writers for this purpose. But something is nudging me away from this interpretation. After all, when we are speaking about the scientist's responsibility, we are referring not only to his participation in public affairs, but also the public social import of his work and its findings, and not simply popularisation. What is at issue is the formation of the scientific world view of the entire people.

For the uninitiated, it is extremely important

to hear from the mouth of an authoritative scientist explanations of new facts of science and new legends emerging on its basis in language they can understand. Such explanations have great public repercussions, even though the scientists themselves sometimes look upon them as a waste of valuable time on secondary goals.

I have used the stereotype phrase "authoritative scientist". I wrote them out of pure habit, without paying any attention to them. In today's society, however, profound meaning is contained in words on authority. In our times this authority is uncommonly high and at times is even hypertrophied to a certain personality cult of the scientist.

What can account for this? The foisting of this authority and cult upon broad segments of the population, and especially young people, from without? The tremendous psychological impact made on people by the great discoveries of the 20th century—from the harnessing of atomic energy to bioengineering?

I think we are talking about objective reasons here first and foremost. The authority of knowledge, its convincing influence on the life of the globe in our century is leading to a sort of cult of knowledge, a cult of the intellect, which is reaching the extreme—the cult of the intellectual. And it is more than millions of people wanting to view the scientist as some ideal, a hero of our time. It is more than a change in historical fashion: today the spotlight is on military leaders, tomorrow, on poets, the day after, on scientists. It is a matter of the thirst for knowledge which has engulfed these millions in the 20th century. Such heroes are in the sphere of their long-term

interests and focus. People themselves, in the cognitive process, strive for this type of landmarks, and do more than admire them as unattainable heights. That is why the authority of the scientist, of science, is a kind of permanent factor in the 20th century. Nor can the researcher simply brush off the fact that the vast majority of his contemporaries are mindful of his opinion.

On the following pages we shall get back to our discussion of authority and the "cult" of the scientist in the modern world. At present let us mention the most important thing for us: yes, the authority of the man of science has grown as never before. But his civic responsibility to people has likewise grown unprecedentedly. It is for this reason that whatever his search for scientific truth may have brought him, he will never be endowed with moral complacency.

Incidentally, this applies not to the scientist alone. As if having foreseen our present-day disputes on the individual's moral responsibility in the context of the scientific and technological revolution, A. M. Gorky wrote in a letter to the playwright Vsevolod Ivanov: "People will want to be more tranquil, so you hope. I do not hope for this. That is, they want to live peacefully, but history will not allow this. After having turned reality upside down, as has been done in Russia, you will not soon put it back on an even keel. Balance is not needed, for that matter, as it is a harmful thing for people."<sup>1</sup>

Today, under the influence of the momentous

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<sup>1</sup> Vs. Ivanov, *Correspondence with A. M. Gorky. From Diaries and Notebooks*, Moscow, 1969, pp. 28-29 (in Russian).

social changes wrought in the 20th century, but not without the impact of the scientific and technological revolution, the march of history has been accelerated to the extent where complacency is becoming inconceivable for mankind. Research spells breakthroughs all over. And the main thing—the integral direction of these breakthroughs—the science of man—is becoming increasingly manifest. Such age-old human virtues as a sense of moral purpose and the stability of the personality, its capacity not to ride with the tide but, if necessary, to oppose it, and the ability to assume responsibility, in a word, the ability to assert one's self, are being examined anew and becoming particularly topical in these conditions.

It is in this that the meaning of the New Year toast Academician Kedrov dictated to me lies: "It is my wish that everyone become an optimist in his work and life in general. What does it mean to be an optimist? A person can easily be one who sees only blue and pink shades of reality and skillfully dodges its difficult problems and hard roads. But I am in favour of a different kind of optimism and different optimists. I toast those who soberly view difficulties but never buckle under them. Those who realise that there are no difficulties which themselves do not contain ways of overcoming them. The times in which we live require precisely this brand of optimism, based on the loftiest sense of civic responsibility. And, while wishing this to all the readers I also wish them happiness. For happiness lies in surmounting difficulties on the road to the summits, and not in thoughtless movement along with the current."



Not so! This sphere of earthly soil  
Still gives us room for lofty doing.

Goethe. *Faust*



## THE HOUR OF INTRODUCTION

A scientist voluntarily had himself committed to an insane asylum fearful that a discovery he had made would be used for anti-humane purposes. His act turned out to be a tragicomedy. Two spies assigned to him posing as insane people and giving themselves off as Einstein and Newton, learned all the scientist's secrets, and, while he was living in seclusion, arms plants were functioning using his formulas and calculations. In this story, told in Friedrich Dürrenmatt's *The Physicists*, encased within the outer framework of comic situations and dialogues was a rather serious question: is the scientist capable of anticipating the possible inhumane use of his discoveries?

In Soviet society science—its research and findings—serves the highest goal of socialism: everything in the name of man, everything for the benefit of man.

Nevertheless, the use of scientific breakthroughs in practice is not entirely problem-free in socialist society either, albeit for completely different reasons than in the West. Pointing to *the fact that today this is a decisive, vital sphere, that industry must have a vested interest in putting to use the ideas and fruit of the efforts of*

scientists and designers better and more quickly, it was stated in the Central Committee Report to the 26th CPSU Congress: "At the same time science itself should be a constant 'trouble-maker', pointing to the areas where there are signs of stagnation and backwardness, where the present level of knowledge could secure faster and more successful advancement."<sup>1</sup>

Does this requirement apply solely to the economic and organisational aspects of the connection between science and industry? Doesn't it make moral demands of the scientist as a person? Isn't it addressed to his civic responsibility for the end results of his efforts?

I am in the, as I have dubbed it, "green room" of the old white-columned mansion of the Presidium of the USSR Academy of Sciences. It is indeed bathed in green: there is green outside the windows, the abundance of flowers on the windowsill, the green carpet, the green upholstery of the armchairs. Even in the large transparent crystal of fianite, this brain-child of Soviet physicists which has literally won the world over in recent years, green reflections predominate. Only a small board on the wall containing semi-erased formulas chalked in a quick hand (just " $q \leq 2$ " is left)—only this board is light blue.

I am in the office of Vice-President of the USSR Academy of Sciences Yevgeny Velikhov, an outstanding theoretical physicist known for his works on plasma physics, magnetic hydrodynamics and controlled thermonuclear fusion.

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<sup>1</sup>*Documents and Resolutions. The 26th Congress of the Communist Party of the Soviet Union*, p. 55.

It is his workplace. But I'd also be right in using this term to describe the laboratory of the Institute of Atomic Energy. And the shop-floors of the Likhachev Motor Works. And the lecture halls of his alma mater, Moscow University, where he is presently a lecturer.

*Question 17. The personality of the discoverer and that of the implementor of ideas merge. Doesn't this heighten responsibility for the imperfection of ideas? That is, the scientist is convinced that his idea will recoup itself when introduced and yield benefit to others. Then unforeseen factors suddenly come into the picture...*

*Question 18. Why do people easily "write off" time, and sometimes even funds, wasted on ill-considered recommendations, proposals and theories? Why not heighten responsibility for forecasts and hypotheses?*

"There is a boundary," says Academician Velikhov, "beyond which research ends and implementation begins, although, of course, both these sides of science are sometimes an indivisible fusion. But a boundary does exist. And decisions have to be taken at this boundary. This, of course, entails a wide range of problems, moral ones included. And there is always a wide range of alternatives. Because today implementation is, as a rule, bound up with big comprehensive programmes requiring both careful study and great responsibility.

"I'll admit, I don't understand very well what is meant by words about responsibility for a hypothesis. The researcher should always be responsible for his findings and suppositions. And, incidentally, at the suppositions and hypotheses stage he still has time to carefully consider all

possible versions. But when the time of implementation comes, it is also the time for alternatives. Only one correct version has to be selected, the Gordian knot of problems has to be cut. This, so to speak, is an act of great civic courage and high state responsibility.

“Such was the case when the decision was being taken to build the world’s first nuclear power station in the USSR. Or to launch the first Soviet sputnik. This is a very responsible moment, especially if there are no precedents for such decisions in world practice, if the trail is just being blazed.

“Today the time is coming for momentous decisions in the problem of controlled thermonuclear fusion. At an end is the purely exploratory stage, when we were ascertaining whether it was theoretically possible to effect a controlled thermonuclear reaction. Thermonuclear researchers were almost certain they would soon prove it. The time has come to take the next decision – to demonstrate that it was technologically possible to resolve this question.

“Of course, if work on the technology of controlled thermonuclear fusion had begun twenty or thirty years later, it would have been possible to obtain much better results, as science and technology would have been that much more advanced. However, it is dangerous to wait twenty or thirty years. One can spend huge funds engaged in endless research without ever coming close to obtaining an economic effect from the monies invested. On the other hand, it is dangerous, of course, to proceed to implementation too early, when research findings do not have sufficient bedrock for major decisions.

“Scientists and power industry workers both here and abroad believe that this bedrock has already been created. The solution is seen as being rather definite – a system of the type of the Soviet Tokamak thermonuclear installation.

“Naturally, in the USSR this solution should be viewed in the context of the overall development of the Soviet power generation industry. A balance has to be struck between controlled thermonuclear fusion and all other – traditional and non-traditional – types of power generation. In adopting such a decision account should be taken of the Soviet Union’s state plans, cooperation with socialist countries, and scientific contacts with capitalist and developing countries. In short, the world situation has to be taken into consideration. And the list of problems could go on and on. Do you realise the burden of the responsibility shouldered by the people taking the decision? I am not adducing any examples from history or hypothetical alternatives. This is the present-day actual situation I am familiar with. Even if I do not pronounce the word ‘morality’, it in actuality permeates this entire situation.”

*Question 19. Doesn't a scientist's too literal conception of his obligation to society limit his scientific and moral horizons? How do short- and long-term goals match up in his work?*

“The aspiration to implement one’s ideas in one’s lifetime is not an obligation foisted on one from without,” says Academician Velikhov. “It is a person’s internal mainspring. Recall Sherpa Tenzing. He had this dream of climbing Mt. Everest. No one pushed him into it. He groomed himself for it. And finally he did it, together with Edmund Hillary. They were the first in the

world.

“When you yourself traverse the entire road from beginning to end, from idea to implementation – that is the ideal to which any real scientist aspires. Igor Kurchatov travelled this road from the fundamentals of nuclear physics to the creation of the nuclear power industry and engineering, and Sergei Korolyov, from the first semi-toy rockets to man’s flight into outer space and to the start of the exploration of the planets of the solar system with the aid of automatic machinery.

“This is a fine destiny! But it is given to people with very strong characters. And the price is very high – truly cosmic overloads inside the laboratory and out. Incidentally, when they started out, nothing even presaged the great (including economic) effect which is becoming evident today. But they believed, and not only believed – they knew that they were working on problems extremely important for the country, for the people.

“In short, the times offer the scientist an opportunity to travel the road from idea to implementation. But he must have the character to take advantage of this opportunity.

“What is real implementation? It is not just some organisational and technological action. The individual and a galaxy of individuals, the collective, are always in the spotlight. Implementation also entails a specific process, breaking with a habitual mentality and way of life, which takes place both within the collective and in the person’s inner world.

“Take the nuclear physicist. Today, what with the transition from the exploratory stage to im-



plementation, a rather complicated situation is taking shape. Even those who were engaged in it in the past and were considered 'pure' physicists, like Academician Boris Kadomtsev, his associates and many other scientists – all now have to acquire vast engineering experience.

"The reason for this is that it would be difficult to pass things on to others right away. As yet our own engineering personnel have not taken shape in this field. They will, of course. With each passing year it is engineers who are to play an increasing role in thermonuclear power generation. Our own chief designers will emerge here too, not only in space research. But physicists will have to adapt themselves as well. In a nutshell, the engineer should be looking over the scientist's shoulder all the time, and the scientist, over the engineer's.

"The moral aspects of the scientist's responsibility to society are frequently discussed rather narrowly by the public at large. Philosophers, scholars and journalists would choose a number of somewhat widespread themes and dabble in each of them for many years. Examples are Bertolt Brecht's play *The Life of Galileo Galilei*, the atomic bombing of Hiroshima and Nagasaki, the Robert Oppenheimer's 'case', and finally, the negative ecological consequences of the large-scale people's transformative activities taking place in the world.

"All of these are extremely important moral mainsprings. And the debates on the scientist's moral choice, on his responsibility for the changes which science dictates to life will not lose their relevance until these problems lose their topicality in reality itself. But, as long as we

are talking about responsibility, there is another, no less important facet—responsibility to accelerate progress, to improve living conditions, to give people greater opportunities for making their lives bright, meaningful and rich, both materially and spiritually. When a scientist finds himself at the forefront of things, he feels and sees new chances to take humanity far ahead; when he is fortunate enough to see farther than others, on him falls a special responsibility to see that his findings are quickly put to use in order to obtain new substantial advantages in technology, engineering and designing.

“He cannot but be a citizen of his own country and think about winning for it bridgeheads of such advantages on all fronts of world science; he cannot but understand that it is on this basis that the country can successfully take part in the international division of labour and compete on the world market with the scientific and technological products of the developed capitalist countries.”

*Question 20. We, a group of associates at a research institute, are working on a certain idea in the belief that it has a great deal to offer the country. But it does not fall in with the plans of our institute. Some feel that we are not doing our work and are shirking our duty. Is this accusation fair?*

“Your project has to be examined first,” replies Academician Velikhov. “Much, of course, hinges on the good judgment of your chief in these situations. After graduating from Moscow University I spent my entire life working at the Atomic Energy Institute. Even though we tackled important state tasks which by themselves called for strict internal discipline and pur-

posefulness, there was always a relative freedom in choosing research tasks at the institute.

"The chiefs traditionally support extensive research. And even if it took researchers into fields far from nuclear physics but produced findings interesting for science in general, Kurchatov gave them the green light, as does Anatoly Alexandrov today. This is sure the correct approach. A team like this, with a high level of demands, and at the same time working with an eye to the future, can come up with completely unexpected ideas.

"No one has yet been successful in his attempts to produce a Procrustean bed for science. Cognition is a Brownian motion to some degree. If you make a movement monotonous and close all coordinates for it, movement in this direction will disappear as well. For so much energy will be lost on grappling with walls that none will be left for forging ahead."

*Question 21. Over the centuries the words "I know that I know nothing" have been the standard for sober self-assessment. But perhaps today this is only a convenient screen for dodging the solving of actual questions with the help of knowledge? At least the scientist should know that his knowledge can substantially influence life and change it!*

*Question 22. Sometimes individual scientists and even entire research teams emphasise only the effect which can be provided by an idea they have proposed for implementation, and do all in their power to overshadow its weak sides in order to prevent the idea from being rejected and to make it fit into the institution's plans and win funding. Doesn't this approach lead to a decline of morals in science?*

“You see, science cannot be defined by any single aphorism or its negation. Science is conservative, yet there should be revolutions in it. We, for example, frequently perceive the struggle between the old and the new as a moral problem. But is this always the case? After all, there are people who indeed know very much and the new ideas which others are trying to prove to them simply do not fit at all into the system of knowledge which they have built. There is a 99 per cent probability that they do not fit correctly, that these new ideas are wrong. But one per cent carries a revolution within itself and suddenly topples the entire well-ordered system...

“Then I must admit that it may so happen that an absolutely honest person will all his life believe in a concept which has been debunked by life. That often happens. Lord John William Strutt Rayleigh was well familiar with the theory of vacillation. However, many facts of modern physics did not blend in with his notions.

“Like life, science is a struggle. It is naive to imagine that everything in science is done in complete harmony, that everyone in it understands one another right off the bat. This is a real struggle of ideas, positions and characters. But it is a struggle for decent, honest goals, and is above board. It is very bad when it starts being linked up with personal aggrandizement, misunderstood authority, etc.

“There are always moral problems in science, of course. The world of science also has to deal with exaggerations of the importance of one's findings, with the desire to push them through by all means in spite of their actual worth. With attempts to give some individual viewpoint the

status of national. Or with attempts to assume credit for another's findings.

"The situations here are not always clear and simple. Nevertheless, there is a very precise watershed here. If a person's desire to bring an idea to fruition is a natural one, then the need to convince his opponents of it is also justified. If there are objections, let there be an open scientific debate!

"A scientist must be exacting toward himself, but also decisive, assertive and persistent. He must have character and the strength to take risks! It should be pointed out that a person often risks his own life: he can live it in vain. He wastes time. And time is his life. After all, as Antoine Saint-Exupéry said, life only has value when there is something more important for the sake of which one may risk his life."

*Question 23. Is it ethical to study the stars when people expect their daily bread from scientists?*

"It is! It was star-gazing that prompted the idea of thermonuclear fusion, which is promising both energy and man's 'daily bread' in the near future. To tell the truth, astronomy has always been the most practical science. Ancient shepherds tended flocks getting their bearings from the stars. Then ships sailed to new continents guided by the stars. And today spaceships use the stars as their guides.

"In short, the stars are quite literally bound up with our daily bread. However, in this question I also see the implication that perhaps we do not need fundamental research which does not offer immediate practical results.

"Scientific development is indeed dictated by economic laws and man's material needs. It

should not be forgotten, however, that it has other catalysts as well—people's inner needs, a thirst to know the world. This is also a built-in quality. Man cannot but strive to fathom the unknown even outside the context of his utilitarian needs.

“Man can likewise learn things which are very dangerous to him. Conceptualising and generalising new facts can be dangerous. The knowledge he obtains can have disastrous results. But even if research gives him alarming, negative findings, they should be known nonetheless. It is up to society to use scientific breakthroughs for man's benefit and to take into account earlier unknown unfavourable factors discovered by scientists and to weaken them or even bring them to naught. But knowledge in itself cannot be a bad, unethical basis.”

*Question 24. Who should the modern scientist be—a Don Quixote, a Hamlet or a businesslike person?*

“Today science, with rare exceptions made for geniuses, needs neither Don Quixotes, nor Hamlets, nor businesslike people by themselves, outside the research team. Modern science, you see, tackles major tasks precisely by teams. And Don Quixotes, Hamlets and businesslike people are essential to these teams. It is important for everyone to work well together. Then the result will be proportional not to the number of people but at least to the square of this number.

“Here in the Soviet Union the entire work atmosphere is geared to this. Party and Komso-mol organisations at higher educational establishments and academic and branch institutes are instrumental in creating it. It is a great art to

combine completely different people, with different personalities and approaches to science, and provide them with proper conditions for joint fruitful work. It is an art, and a science, too!"

Academician Velikhov claims Igor Kurchatov to be one of the scientists to have mastered the art of running big research programmes and rallying the elite of Soviet science around them.

"Kurchatov possessed the amazing gift of drawing into the common effort researchers who were completely unlike each other and himself. Furthermore, like any other leading celebrity, he had no qualms about hiring people who far surpassed him in some aspect. He himself complemented them in some other aspects. He was able to arouse in each colleague, even the youngest, a sense of the importance of his work, and to quickly find his place.

"However, whereas I am judging about Kurchatov more from accounts of him by people who knew him well, I had the pleasure of working under a scientist of his stature. I'm talking about Anatoly Alexandrov. I have worked with him and continue to work with him at the Institute of Nuclear Energy, and here, at the Academy Presidium, too. I must tell you that the atmosphere which he creates (I'm not talking about everything else – he's a farsighted scientist, a practical man, and he has an excellent engineering mind) is a very healthy one, one conducive to creative work.

"A person has to feel trust. Then he will put out more. Then he will take risks. People can somehow get by without making mistakes. But this is impossible in science! If you do not feel your chief's trust and think only about not mak-

ing mistakes, all this will ultimately degenerate into pure bureaucracy. Because there are no roads in science which can be traversed without making mistakes, about which you can say you know where they're leading."

*Question 25. What features set apart the Soviet scientist from, say, the scientist from pre-revolutionary times or, for that matter, from the modern foreign scientist?*

Velikhov grinned: "An entire philosophical treatise can be written on this issue, but this isn't my field." Then he pondered awhile, and here is his answer.

"The all-embracing work of science so typical of our modern world is also developing a certain overall, global 'style'. Both in this country and abroad there are large research teams geared to major programmes. This has been a sign of our day. At least since the early forties. It should be pointed out that world science and practice take a great deal from us in terms of organisation and planning.

"In general, when we are dealing with such a homogeneous material as research, a great deal – work methods, scientific language, etc. – proves to be universal. In this sense scientists are a rather responsible and intelligent segment of society which speaks a basically common language. It is easier for them to establish contacts amongst themselves irrespective of the differences in the social systems of their countries and all other differences. For this reason scientists very often act as a kind of ambassadors of good will. The Pugwash movement is one example.<sup>1</sup>

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<sup>1</sup> A public movement of scientists for peace, disarmament.



Science is a fine way of building bridges between countries and peoples. It is important to point this out. While setting apart the particular it is important to understand the general.

“When speaking about the traits of the scientist of our socialist society, one should also be mindful of the fact that they were not shaped right out of the blue. The Russian intellectual, no matter who he was, a district physician or a world-famous scientist, acutely felt from time immemorial the need to put his labour at the service of the people. The impossibility, to use today’s phraseology, of implementing the achievements of science in practice (by virtue of tsarist Russia’s backwardness and the lack of farsightedness, the indifference and narrow-mindedness of the autocratic government apparatus) was perceived by the country’s finest scientists at the time not as liberation from ‘additional difficulties’, ‘saving of time’, etc., but as a personal tragedy.

“These, so to speak, are the moral prerequisites for the type of scientist which predominates in the Soviet Union today. The triumphant October Socialist Revolution initiated new interrelations between state power and science, between the Soviet government and the Academy of Sciences. During the Soviet years our science has taken shape, run by such an effective headquarters as the USSR Academy of Sciences. Science now interacts intensively with the

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ment, international security and scientific cooperation. Its initiators were Albert Einstein, Frédéric Joliot-Curie, Bertrand Russel, and others. The first conference of this movement’s supporters was held in Pugwash, Canada, in 1957.

economy. A mighty socialist economy unimaginable at the turn of the century has been formed. It is on this material basis that the new scientist has taken shape, a scientist closely connected with industry and agriculture and tackling major state tasks. A scientist with the highest degree of social responsibility. A scientist and citizen, who does not shirk active involvement in public affairs.

"This is evidenced by the life and work of such people as Ivan Bardin, Nikolai Vavilov, Sergei Vavilov, Vladimir Vernadsky, Nikolai Zhukovsky, Abram Ioffe, Vladimir Obruchev, Ivan Pavlov, Kliment Timiryazev, Alexander Fersman, Sergei Chaplygin, and many others. It is these scientists who laid the moral foundations of the fledgling Soviet science and handed down the baton of their scientific schools to new generations of researchers.

"What is especially typical of the character of the Soviet scientist? The combination of a high degree of social responsibility, i. e. service to society and the state, with deeply humane aims of his plans and practical work. I don't claim that this is typical of Soviet scientists alone. But it is typical of them to a very great degree."

It is probably no accident that Academician Velikhov gave precisely this answer to the question about the qualities of the Soviet scientist. He himself went through the fine school of the formation of the scientist which closely involved tackling important social problems.

Velikhov recalled a physics department Komсомol organisation conference at Moscow University while he was in his second year. The discussion ranged on the type of physicists the

Soviet Union needed and the research and scholastic style at the department required for this. The recommendations and requests made at the Komsomol conference were so serious and justified that measures followed which greatly changed life at the physics department. Top scientists were called in to teach and do research. Many of the people who were actively engaged in organising the conference and the debates later won country-wide renown. One example is Vyacheslav Pismenny, who did a great deal to set up student construction teams.<sup>1</sup>

After graduating from Moscow University, Velikhov was given a position at the physics department under Lev Artsimovich. Velikhov helped Pismenny build a large plasma physics laboratory, which the latter set up together with his colleagues on the student work teams.

At present this is one of the biggest and most productive physics laboratories to have been built over the past 20 years. Its momentous results have been awarded the State Prize of the USSR. Many of the students who pioneered it went on to become Doctors and Candidates of Science. But it is the birth of the laboratory that Velikhov recalls. It was set up in a unique fashion, with the students' hands—they did everything themselves. Aside from the desire to carry out the project they had the knowledge to do it.

A high point in Velikhov's life was the day he became chairman of the Young Scientists' Council under the Komsomol Central Committee. He was sent in this capacity on business trips to

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<sup>1</sup> Voluntary work groups comprised of students in the USSR engaged in the construction of industrial and cultural facilities during their holidays.

Tyumen, the Krasnoyarsk Territory, and to many other distant parts of the country.

When asked about the most memorable events and impressions in his life he says that never did he see anything more striking than the carnival in Cuba during the World Youth Festival in Havana. But if we mean events and impressions which have left the biggest imprint on his consciousness and influenced his attitude to life, he points to the Komsomol sponsorship of the Atommash nuclear power engineering facility. Academician Velikhov indeed speaks with particular warmth about Atommash.

...The main impression which I take with me from this green room is that there is no sharply defined line where research ends and the "zone of implementation" begins.

Modern science has indeed merged with economics and has itself become a productive force. This requires specific moral qualities of the researcher. He has to combine "ice and fire" in his moral bedrock; he has to be dynamic and persistent in bringing his ideas to fruition, to their implementation. Yet, it is science's impact on life that dictates to the scientist a special caution, scrupulosity and moral soberness at the hour of implementation. In short, he perceives his effort to have his ideas put into practice as his moral duty. Science needs such qualities, but it also forms them. It draws the researcher into an indefatigable endeavour for the end result, for the implementation of his designs in metal, in experimental and then industrial installations, in new machines and computers, in orbital stations. It leads man from word and thought to action, for which the wide, wide world is still sufficient and will always be sufficient.

Thou gav'st me Nature as a kingdom grand,  
With power to feel and enjoy it. Thou  
Not only cold, amazed acquaintance yield'st,  
But grantest, that in her profoundest breast  
I gaze, as in the bosom of a friend.  
The ranks of living creatures thou dost lead  
Before me, teaching me to know my brothers  
In air and water and the silent wood.

Goethe. *Faust*



## LOGGER OR FORESTER?

When I looked closely at the features of this man, the youngest member of a legendary four-men Arctic exploration team,<sup>1</sup> I thought back nostalgically to my childhood before the war. During the moments when they were being greeted by a Moscow decked out in festive garb, in Leningrad, on the floor of a room whose windows faced Uritsky Square, little boys were playing "arctic explorers". A large book from their father's library served as an ice floe, and others, smaller ones, were ice-breakers plowing through it....

Even though this man had achieved much in life (at 28 he was Hero of the Soviet Union and at 29, a corresponding member of the USSR Academy of Sciences), he wrote 40 years after that famous expedition: "...Although I have several honourable titles valued by any Soviet person, I am nevertheless just as proud of the title which the people gave our crew – 'Papaninite'."<sup>2</sup>

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<sup>1</sup> In May 1937 the North Pole 1 Soviet drifting research station was set up at the North Pole. Researchers Ivan Papanin, Pyotr Shirshov, Yevgeny Fyodorov and Ernst Krenkel spent nine months on an ice floe.

<sup>2</sup> I. D. Papanin, *Life on an Ice Floe*, Moscow. 1977, p. 310 (in Russian).

I unwittingly began our conversation with an "Arctic" question:

"Much is being said today about environmental pollution having become a global problem, with DDT being found even in the Antarctic. Is the Arctic heavily polluted in comparison to the times of the North Pole 1 drifting station?"

Academician Yevgeny Fyodorov frowned:

"The situation should not be exaggerated. The Arctic is one of the regions of the globe which has been little affected by man's transforming activity over the past 40-45 years. Relatively speaking, of course, for the Arctic is being explored at a rapid pace. The transnational and transcontinental shifts of pollution are quite another matter. They are reaching both the Antarctic and the Arctic."

It was not by chance that I approached Fyodorov concerning readers' questions about environmental protection and several moral aspects of it.<sup>1</sup> The man-nature interrelationship is an important part of the problems studied at the Institute of Applied Geophysics which he founded and ran. For many years he was in charge of the Weather Service Administration under the USSR Council of Ministers. He was a member of the USSR State Committee Collegium for Hydro-Meteorology and Control of Natural Environment, and a member of the USSR Supreme Soviet Presidium. He headed the Soviet Peace Committee and was vicechairman

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<sup>1</sup> When this book was being readied for printing in Russian I received news that Academician Fyodorov passed (December 30, 1981). He had read the text of this chapter several days before he died.



of the World Peace Council. His book *Man and Nature: the Ecological Crisis and Social Progress* generated great interest here and abroad.

*Question 26. Today scientists in many fields are doing research into the rational utilisation and protection of natural resources. This very notion is bound up with responsibility for the future. What is a scientist's moral responsibility for the natural environment? When we are talking about the destructive force of scientific and technological progress as regards the environment—this is taking place right before our eyes. As soon as the conscience and responsibility is mentioned, one hears and reads something like abstract biblical precepts.*

“Why is this so?” queries the scientist. “The conscience and responsibility are very tangible notions. They do not exist apart from the life of society. Let's look at the USSR Constitution. It directly mentions responsibility for the environment both on the part of the state and each of its citizens. It is a common responsibility.

This feature is an invariable feature of socialism. At the same time our socialist conception of responsibility for nature is readily understood by people in every country on every continent. It coincides with the aspirations of mankind. It is completely correct in this regard that exploiting natural resources and protecting them from being exhausted are connected with moral responsibility for the Earth's natural environment. These are not abstract notions. What responsibility is can best be judged from how these notions are implemented in reality.

“It will be recalled that it was at the Soviet Union's initiative that an international agree-

ment was signed on a prohibition of the use of means of influencing the environment for military or other purposes. It was the USSR that tabled at the 25th General Assembly a draft resolution on the historical responsibility of states for the preservation of the natural environment for the present and future generations. The session endorsed this resolution and instructed the UN Secretary-General to prepare a report on the harmful effects of the arms race on the environment for the next session.

“This question, however, also involves the destructive force of scientific and technological progress in relation to the environment. One cannot agree with this. Practically any scientific and technological breakthrough can be used both for constructive purposes, for heightening people’s well-being, and for destructive purposes. Neither science nor technology are themselves to blame if they are used for destruction. One can only fault people, the social structure and socio-economic conditions. It is important to point this out, since talk about the destructive power of scientific and technological progress *per se* seems to rid man of his civic and moral responsibility.

“People can indeed accomplish a great deal. It is very important to inculcate an ‘ecological conscience’ in them. While providing an opportunity for major transformations of the environment, scientific and technological progress sometimes leads to consequences harmful to man. But it also produces means for protecting the environment which helps prevent disorder in its natural development. Suffice it to mention the birth of waste-free production, technological

processes which reduce pollution of the environment to a minimum or eliminate it altogether, and the increasingly widespread use of closed-cycle water supply systems.

"The scientist's moral responsibility for the environment lies in his consciously invigorating nature-protecting trends in scientific and technological progress and reducing to naught trends which threaten the ecological balance. As to environmental protection on a global scale, we can add the moral responsibility of the leading scientists in different countries for unity of action, for world-wide cooperation."

*Question 27. Some authors state that the environment can be influenced ten times more strongly and protected ten times better. Is this practicable?*

"This is quite the case," was Academician Fyodorov's answer. "Natural resources can be tapped more fully and intelligently and at the same time measures can be taken which rule out negative influences on natural processes. For example, in extracting minerals we still do not make full use of all the contents of the ores. New technological breakthroughs (their appearance is not only wishful thinking but also the inexorable march of scientific and technological progress), which will enable us to draw more fully from natural conglomerates individual substances man needs and to comprehensively utilise all components comprising these conglomerates, and will give us an opportunity to develop natural resources more intensively and better protect the environment at the same time.

"Man cannot get around transforming the environment and using its wealth. It should be kept in mind, however, that not man alone, but

any form of life will transform nature. Oxygen, for example, has become a vital element in the atmosphere as a result of the action of bacteria and vegetation. Limestone deposits are a product of the remains of tiny sea organisms.

“It is not a matter of preventing any transformation. This is impossible. It is an impossible dream. What is at issue is to influence the environment in strict compliance with scientific norms. Are we able to make these norms? We are. Admittedly, at the present juncture ecology and the totality of sciences engaged in ecological problems are not sufficiently developed, for which reason our actions are poorly mapped out and cause unforeseen environmental changes undesirable for us. But this is not some natural pattern or an inevitable feature of human activity. It is simply an insufficient—at the given stage—ability to estimate consequences; it is a definite level of scientific development, a specific technological level of the economy. But this level will not remain unchanged. The fields of science in question have been developing rapidly over the past decades and years. They have to be developed even more quickly so as to learn to calculate not only immediate consequences but also long-term ones, and to compensate in advance for those which are undesirable.”

*Question 28. We know that medicine is impotent in many instances. Nevertheless, none of us, upon feeling ill, will reject a physician's services solely on the grounds that he does not have a panacea for all illnesses. Why then are those who are protecting and “treating” the environment expected to come up with an immediate solution to all the problems plaguing nature? Why are there*

*so few people who realise that there are ecological problems which man is presently incapable of resolving? Finally, what are the priorities in tackling environmental protection issues?*

“All this is true up to a point. There are some problems in medicine which are indeed viewed as unsolvable or difficult to solve. But if we’re talking about protecting the environment, about hopes for our interaction with it, a different picture comes into view. These are not formidable difficulties of science, but a result of the fact that not enough attention has been focused on this aspect of its development.

“As to the expectations for a comprehensive solution to the environmental protection problem, they, while on the surface showing a heightened, extremely developed ‘ecological conscience’, in reality frequently attest to an insufficient level of both civic and ecological education. Demanding ‘total environmental protection’ while making believe that the economy and people’s needs have nothing to do with you, is much easier than tackling the actual issues at hand.

*Question 29. Why are professions involving the development of natural resources often viewed by the public as “evil” or “cruel”, while those connected with their protection, “kind”? Why is a minus sign hung over a logger and a plus sign over a forester? Why is the former “bad” and the latter “good”?*

“Does timber have to be cut? It certainly does, because it is a source of many things modern man needs. But should it be cut in such a way as to reduce the area of forestland, without a thought to the morrow, to our descendants? No, not only is this unwise, it is economically unfeas-

ible. Just as is the approach where woodlands are not touched at all and trees rot at the root. There is only one solution: the logger and forester should work together to run the country's timber industry intelligently.

"You won't explain much by calling one occupation 'kind' and another 'cruel'. Every occupation has its 'kindness' and its 'cruelty'. When a combination of a sensible and thrifty attitude to the environment becomes a widespread phenomenon, we will no longer link kindness solely with the side opposite to the one involving the negative aspects of using natural resources."

Academician Fyodorov was right, of course, when he said that it is not a matter of an "evil" logger and a "good" forester. The very counterpoising of them is some poignant symbol. What is meant is the person who harnesses natural wealth and the person who protects it. But the very opposition of these two principles, which in effect should be in harmony, is not contrived. For centuries private property has alienated the economy and ecology. By eliminating private property, socialism has removed the fundamental cause of the contradiction and laid the bedrock for new relations between society and the environment in which, according to Marx, "socialised man, the associated producers, rationally regulating their interchange with Nature, bringing it under their common control" achieve this "with the least expenditure of energy and under conditions most favourable to, and worthy of, their human nature."<sup>1</sup>

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<sup>1</sup> Karl Marx, *Capital*, Vol. III, Progress Publishers, Moscow, 1971, p. 820.

These words contain the moral programme of the relationship that should exist between man and the environment in socialist and communist society. They should be most worthy of human nature.

But it will take years of course to fully bring to naught this "rivalry" between forester and logger both in the economy and in people's consciousness, to achieve unity between *Homo sapiens* and *Homo habilis*—intelligent man and acting man, a person in whom an active worker in the workshop of nature and a protector of its temple's treasures are combined.

The formation of such an individual is a sign of the times and of socialist society. But this task is not a simple one; it requires both time and a tolerant ecological education in communion with the practice of a socialist use of the environment. For centuries man had been taught that this unity is impossible. Either the temple or the workshop.

When the prominent Soviet prose writer Valentin Rasputin was asked what he would have wanted to have been had he not become a writer he replied: "A forester. It is a fine occupation, clean, good, joyous; it is one of those very rare jobs today where everything from beginning to end is useful and justified, everything serves man and the beauty of the world around him, and the moral and physical health not only of you and me but also of our children and grandchildren."

The potential of Russian literature cannot be divorced from the thickets, glades, expanses and springs of the Russian woods. Russian writers have always been ecology-minded. But it is only

when wherever you go, each member of society will combine the qualities of one who draws from nature in full measure and a person who protects it that it will be possible to say that environmental protection has been ensured as an asset of the human personality and has been attuned to conditions most deserving of human nature.

*Question 30. Why is it so easy to convince modern man of the importance of environmental protection globally and so hard to teach him elementary care for nature right at home?*

*Question 31. Why do people who observe moral norms vis-à-vis other people and consider themselves good workers and kind citizens act so inhumanly at times toward animals, flowers and wildlife?*

Academician Fyodorov laid the blame on upbringing:

“These shortcomings are manifest not only as regards nature. It is a known fact that very many people can judge correctly about good and bad actions, but are much less capable of desisting from bad acts and of doing good ones in their own lives. A definite role here is played by the fact that a person’s behaviour as regards the environment is only now coming into the lime-light. For a long time this question was just not studied.

“In the Soviet Union the notion still predominates that the country’s natural resources and expanses are boundless. This is correct in a way. In comparison to other countries the USSR possesses vast natural resources and huge expanses. For many years, however, this spawned a careless attitude toward the environment, and left an



imprint in the people's consciousness. It has become a habit. So there indeed are some objective reasons. However, even though the country today is still fabulously wealthy in natural resources, we cannot view either our resources or our expanses as unlimited given our present-day needs and scope of production. This requires man to adopt a new attitude to the environment, including as regards everyday ecological standards.

"A person cannot 'rid himself' of his own moral principles. Either they're there—and they manifest themselves in everything: his attitude to his job, to others, to the environment—or they aren't—and then cruelty to nature is an expression of his cold attitude toward others. In short, I do not see a reason for separating a 'moral' attitude to the environment from a person's moral make-up in general, from his moral attitude toward other people.

"It is another matter that the range of society's heightened focus and, therefore, the range of moral values in it eventually come to include spheres which this range formerly did not encompass or almost did not encompass. In this sense ecological problems have become thorny moral problems of late."

*Question 32. Perhaps it is worthwhile creating a moral ecological code or at least including in existing moral codes, oaths, etc. a new precept—on protecting the environment?*

*Question 33. Ethics has always been a science which studied interpersonal relations. Do the times demand that we create a new, ecological ethic, which would determine "good" and "evil" in relations between man and the environment?*

"I have already stated that there is no special morality in man's attitude toward nature which differs from man's attitude toward his fellow man. The very terms morality, good and evil, humanism and inhumanity are inconceivable without being correlated with man. Consequently, there should not be a special ecological ethic."

*Question 34. What should one be more afraid of—the atomic or ecological end of the world?*

"One has to be apprehensive above all of a world thermonuclear conflict, of course. As is well known, the policy of peace pursued by the Communist Party and Soviet government is aimed at averting this conflict. It would cause irreparable damage to the environment and alter it substantially and in a manner harmful to man. But this would not, of course, be the main consequences of a thermonuclear conflict, because after it the environmental protection problem would hardly have any topical significance at all.

"One should not expect an ecological 'end of the world'. Yet today one should not view the environment as something limitless, inexhaustible and invariably stable. Man's influencing of the environment has been stepped up to such a degree that it is now essential to strictly map out this impact to prevent it from becoming uncontrolled.

"Karl Marx wrote more than a hundred years ago that "cultivation when it progresses spontaneously and is not *consciously controlled* ... leaves deserts behind it".<sup>1</sup> He adduced the fall of

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<sup>1</sup> Marx, Engels, *Selected Correspondence*, Progress Publishers, Moscow, 1975, p. 190.

ancient civilisations as examples. But his thought was geared to the future, of course. This was a very far-sighted glimpse at the development of relations between civilisation and the environment. The time has come when man's culture and the whole of civilisation has to develop in a conscious, intelligent manner for his benefit. The fact is that today actions vis-à-vis the environment in one country can have far-reaching consequences for the well-being of the populations of neighbouring countries, and for entire continents for that matter.

"Or take another example. Oil slicks cover the surface of the World Ocean, and this is having a definite impact on water circulation in the environment, and, consequently, on the climate. The polluting culprits here are individual though not solitary countries, and the consequences affect the whole of humanity. Tropic forests are being cut down very rapidly, and woodlands are a basic element of the environment which puts oxygen into the atmosphere.

"Thus, there exists a very strong interplay among countries as regards their influencing the environment. It is for this reason that extreme danger is posed to the environment by the course of the Reagan Administration for attaining military superiority and for undermining international cooperation in various spheres. If there is no collaboration among countries and no opportunity to pool efforts and substantial funds for implementing major environmental protection projects on the global scale, mankind will find itself in a great deal of trouble. And in the decades to come, too.

"In order to protect the environment it is im-

perative above all to ensure peace and implement the Peace Programme for the 1980s proclaimed at the 26th CPSU Congress."

Listening to Academician Fyodorov's words about the struggle which this country is waging for peace on earth and, consequently, for life in the biosphere, I thought about how at all times the notions "environment" and "country" were indivisible, and that love for one's country began with love for one's home and the nature around it. Today man is able not only to mentally picture but actually see the entire Earth—from terrestrial orbit. The vantage point of the individual and of mankind for looking at the world has broadened dramatically. And modern man more and more frequently feels the entire planet Earth through his homeland in the endless expanses and worlds of the Universe.

A sense of globality was established in Soviet life when man went up into space. It should not be forgotten, however, that this sense was prepared by the entire cultural and intellectual experience of mankind. The Soviet way of life, with the vigorous humanism inherent in it, and the struggle for peace and social justice, instills in the individual a profound interest in coming to know the environment and a desire to change it for the better. Soviet reality itself has formed an important quality in the people of socialist society—a unity of their sense of country and patriotism, and a sense of internationalism and involvement in all of humanity's joys and sorrows. It is this unity that engenders our concern today for the destiny of peace on Earth.

War has always impeded normal and natural relations between man and the environment.

This was discussed in the *Frontline Diary* written in 1941 by the Soviet author Yevgeny Petrov during the Battle of Smolensk: "A new day came, the sun rose amidst the incessant artillery thunder; the dawn was uncommonly beautiful. But I found myself perceiving this beauty with my mind alone. 'This is probably beautiful,' I thought. But my heart didn't tell me anything. There is no beauty during a war. The day Hitler is defeated, the first day of peace, people will understand again how beautiful the nature which surrounds them is. And now this barren oblong hill, which was just purple in the dawn and immediately became illumined with the sunlight and became lemon-yellow and shining, is, in essence, not even a hill. It is Height number such-and-such. Smolensk is visible from it, and fierce fighting has been going on for two weeks to take this height. That Russian birch-tree standing by the road is not a birch at all, but a single tree. That's the way it's designated on the map. And the stream is not a stream, but a boundary. And the clearing in the forest is not a clearing but an excellent position for a fire point.

The war had taken everything away from nature."<sup>1</sup>

I accidentally dug up this book, printed during the war, on a library shelf and was reading it on a summer's day on the bank of the Pakhra River outside of Moscow. The green tops of the birches on the hill beyond the river were rustling in the wind. By the bank a ray of sunlight penetrated the foliage and reached the bottom, and it

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<sup>1</sup> Y. Petrov, *Frontline Diary*, Moscow, 1942, pp. 29-30 (in Russian).

shone dull, brownish gold through the murky water.

All around me was the voluminous, stereophonic nature of mid-Russia. The sun-permeated trees rolled to the horizon, all bathed in sultry honey-like aromas. The chicory was turning a pale, northern-like blue by the shoulders of the country roads. There were so many wild strawberries in the glades that summer that people would fall asleep and dream of the red fruit in the green grass. There was peace all around.

Yet how superb, across the tumult braided,  
The painted rainbow's changeful life is  
bending,  
Now clearly drawn, dissolving now and faded,  
And evermore the showers of dew descending!  
Of human striving there's no symbol fuller:  
Consider, and 'tis easy comprehending—  
Life is not light, but the refracted colour.

Goethe. *Faust*



ON THE OTHER SIDE  
OF THE RAINBOW



A rainbow unexpectedly appeared amidst the intertwined wires and mass of devices and transducers. Its dalliance seemed to offset the world of formulas, integrals and graphs. In reality, however, this rainbow is on a poster (I see it in one of the laboratories of the Institute of Physics of the Estonian Academy of Sciences) – it is simply a scale where sectors of the light spectrum in which various types of lasers function are marked off.

From a distance this interplay of beauty and blue-collar research work may seem symbolic. It is simply not noted here. Even though fine multi-coloured rays shine in physics laboratories, boggling the imagination of dilettantes, light for those who work here is quanta, energy levels of atoms, splashes of graphs and chains of formulas. Working “on the other side of the rainbow” is their life.

Incidentally, the everyday work of Peeter Saari and of the institute sector he heads – optics (the interaction of light and matter) – is nevertheless an area of physics closer to poetry and the diverse beauty of nature. While not posing such a task directly, it explains the physical fundamental cause of beauty.

Take luminescence, which Saari has been working with since his student years. It has an exact scientific definition. But can it fully express the troubled glittering of fireflies in the night forest or the will-o-the-wisps in swamps or the fantastic luminescence of warm southern seas? No less convincing is the poetic definition of luminescence given by the writer Konstantin Paustovsky in his "Black Sea": "The sea was burning. It seemed that its bottom consisted of crystal illuminated from below with moonlight...

"A white flame ran to the shore, and the entire bottom was visible. Stones and pieces of metal lying under the water were covered by a thin fiery dew.

"...Streams of liquidy magic light slithered through the fingers with a splash."<sup>1</sup>

True, that which Peeter Saari is directly studying is indeed far removed from the boundary of our ordinary perception which does not easily lend itself to visible analogues. In 1981 he, together with his teacher Carl Rebane, President of the Estonian Academy of Sciences, corresponding member of the USSR Academy of Sciences, and Vladimir Khizhnyakov, corresponding member of the Estonian Academy of Sciences, received a diploma for the discovery of a new natural phenomenon—"hot luminescence". Prior to this he was awarded the Lenin Komsomol Prize for a series of experiments in this field. This has nothing to do with our everyday notions of "hot" and "cold". What is meant is irradiation, which splashes out from the

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<sup>1</sup> K. G. Paustovsky, *Collected Works* in six volumes, Vol. 2, Moscow, 1957, pp. 89, 90 (in Russian).

depths of an "unsettled" substance.

I will not, however, burden the reader with an account of all the finer points of this truly precision work. All I'll say is that whereas in the not too distant past indirect methods were the only way of receiving information about the superfast processes taking place in molecules, today laser engineering makes it possible to use direct methods, too. For example, the very registration of hot luminescence was once associated with experiments verging on the fantastic, while today Saari's sector is tracing its changes in time.

The centuries have passed unhurriedly over the hills of Tartu. Nearby, about a half-hour's ride by bus, is the Institute of Physics, with its picosecond lasers, which give birth to inconceivably short impulses.

What is the shortest unit of time for us? The second. Speaking less definitely – the instant, the moment. Physicists have already built lasers which irradiate impulses of light to within picoseconds and their fractions. A picosecond is one trillionth of a second. Imagine: a light ray can travel a distance seven and a half times the earth's circumference within one second. It traverses but 0.3 millimetres in a picosecond.

Picosecond spectroscopy as a new scientific field is being born and established right before our eyes. The first international conferences devoted to it were held in 1978: in the United States in spring and in Tallinn in autumn (incidentally, Peeter Saari was deputy chairman at the latter).

Thus, Peeter's life ambition and each new work day are connected with fundamental research into matter and energy at the molecular

and atom levels, which in turn have directly to do with the creation of new materials, especially for spheres of the economy, science and technology involving semiconductors and quantum generators, and with the study of the photosynthesis mechanism. This is the main thing to which he devotes his time and for which he is best known in the scientific community. However, "hot luminescence" and picosecond lasers were not the subject of my conversation with him.

*Question 35. Speculatively I realise that I am no better than my acquaintances in the humanities. But to tell the truth, I can't help objectively noticing that the absence in their education of such fundamental fields as mathematical analysis, quantum mechanics, and the theory of relativity makes their perception of the world and their thought processes more approximate and metaphysical and less dialectical. In short, I, a junior researcher, feel capable, if need be, of understanding the humanities, art for example. But are my humanitarian brethren capable of mastering the basics (not on the school level, of course) of modern physics or mathematics?*

*Question 36. Einstein played the violin. The chemist Borodin wrote operas. But I have come across so many people among ordinary researchers and engineers who flaunt their "physical", "mathematical", or "biological" one-sidedness and put the artist or actor a step or two below themselves. Doesn't a person lose too much in forming his character from the gap between intellectual and artistic principles, which the modern scientific and technological revolution is fraught with?*

I have chosen these to be the first questions I have asked Peeter Saari for the simple reason

that, judging from the stories of his friends and colleagues, art is a sphere of his special interests. At the philosophy seminars for young physicists which he conducts topics are frequently debated which deal with the correlation between artistic and scientific creativity. Later, after having visited with him, examined his collections of book-plates and publications of *Kalevala* from different countries and listened to his views on painting, I took note not only of his interest in art but also his subtle and even sophisticated taste. But more about this later. Now Peeter smiled softly and touched his fair beard:

“You know I’ve probably been lucky in life. Tartu is a city with a rich history and rich cultural traditions. How can we, physicists, put, say, actors below ourselves when we are proud of our theatre, one of the most interesting in the country, when we have been taught to respect it from our university days?! Moreover, it’s a small city, and contacts between the scientific and artistic communities are rather close, though we feel they still aren’t close enough. That’s the way things stand: the people at our institute like art, but they’re here, naturally, for other reasons.

“But I do understand that the author of this question did not make up the people he’s writing about.

“When a young physicist or mathematician is well-versed in music, painting and literature and on this basis assumes the right to judge professionally about art by virtue of the fact that both his education and the very nature of his work in the natural sciences indeed sharpen analytical thinking, the judgments of this physicist or mathematician can seem unusual, original, fresh

and even innovative in comparison to 'traditional' judgments of experts.

"Nevertheless, a vast gap lies between a reader's or viewer's opinion, even if this opinion reveals the author's originality of thought, and genuine penetration of the secrets of artistic creativity. In any event, the 'first fiddle' of 20th century physics, Albert Einstein, had enough tact not to consider himself first fiddle even in a small musical ensemble, although it is said he played well.

"Of course, there are at times happy symbioses of artistic and scientific talent. I don't know, for example, which is more correct to say: "The chemist Borodin wrote operas" or "The composer Borodin discovered new chemical laws". But this is the exception rather than the rule. And for this reason, while loving art and even engaging in it as an amateur, it is very important to understand that this is a complex world with its profound laws and secrets. Mastering them requires a special talent, different from that in science, plus a great deal of experience, which is acquired through many years of hard work."

*Question 37. Does our age need erudites; how practical are they today?*

*Question 38. In science there are brilliant figures and there are present-day modest Dymovs.<sup>1</sup> Chekhov's sympathies lie with the latter. How do you feel?*

"I agree with Chekhov. All I will add is that

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<sup>1</sup> A physician and hero of Anton Chekhov's short story "The Grasshopper". He is an "unobtrusive" extremely modest man, who dies while saving a sick child.

even a brilliant celebrity can be a modern Dymov. One's attitude to work and one's moral responsibility for the task at hand is what matters, and not the fact of being an extravert or introvert.

"Specialisation in science has reached the limit. Nor does today's integration of it have precedents in the past. Each new step into the secrets of nature is paid for by a high concentration of intellectual efforts. Despite the fact that these are usually collective rather than individual efforts, I feel that the time of the erudites is not yet past. In any event, I can definitely name some truly erudite people who have lived in the 20th century: Vladimir Lenin, Norbert Wiener, Maxim Gorky. We won't mention living individuals. But there are such erudites today."

Peeter Saari's point of view may seem controversial. It is based, however, on a rather solid foundation. We frequently recall Engels' words from *Dialectics of Nature*: "It was a time that called for giants and produced giants, giants in learning, intellect, and character."<sup>1</sup> But it is usually pointed out here that they apply to the Renaissance era, and that in our day erudites have supposedly given way to "collective erudites" – big research organisations.

Yet, these words can be applied to the future as well as the past. Moreover, and I feel Peeter Saari is correct here, they can well be said of the 20th century. It has also needed and produced giants of the intellect, spirit and character. We are not always inclined to admit this obvious

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<sup>1</sup> Frederick Engels, *Dialectics of Nature*, Progress Publishers, Moscow, 1974, p. 193.

fact—at least as regards our contemporaries—either by virtue of prejudices of the moment or because “great things are seen at a distance”.

Never before has the individual merged so indivisibly with the group as in the 20th century. Yet never before has he received such opportunities to develop diversely his abilities and talents and to satisfy his thirst for knowledge and action. Never before has man felt so acutely the intolerable contradiction between the endless horizons of cognition and his short lifespan.

As long as this contradiction exists—and it will exist as long as man exists—there will also be fertile soil for erudition and erudites themselves. Only the meaning of these notions will change, of course. Much of what was formerly a sign of the encyclopaedically educated individual will now become the concern of computer memory cells. Man will free his brain for conceptualising the most general associations and processes of the Universe, for penetrating its most distant horizons.

For a person who confines his interests to the environs of his ego, the rest of the endless world often becomes scattered in a chaos of unrelated things, facts and phenomena, and the person gets bogged down in a “stream of consciousness”. However, the person who absorbs the entire world with trust and enthusiasm, without deifying but not underestimating his own ego, and tries to find common links connecting the world into a single entity—this person contains in his very views of the world an antidote to the dogmatic elevating of his personality over everyone and everything, to nonacceptance of that which lies outside his narrow specialisation, and



to an omnivorous acceptance of the world in the form of a hodge-podge of heterogeneous ideas, facts and impressions.

*Question 39. It seems that people have already figured out that the individual's moral and educational level are not directly proportional to one another. Is there perhaps an inverse proportion at work here? After all, it is people of the older generation, less educated people who are frequently the propagators of morality, while many young people with diplomas view moral norms as a kind of convention.*

“This is a very complicated question. However, it is oversimplified in the way it is phrased. After all, an educational level buttressed by a diploma does not necessarily mean erudition. It seems to me that the moral level of the individual is always subjected to danger when proportions between its moral level and intellect are upset.

“People of the older generation, our teachers (at least I can state this about my own teachers) are summits to which many young people have a long way to go to reach in terms of erudition in the genuine sense of the word, of depth and breadth of knowledge. Incidentally, while being people of high moral calibre, they do not like to preach. Thanks to individuals such as these the growth of the educational level of the new generation is being accompanied by the development of moral qualities. The moral foundations of science are being solidified from generation to generation, although the knowledge obtained by it is being augmented just as quickly.

“I feel that it is basically wrong to place stringent moral norms at one pole, associating it with people of the older generation, and a high level

of knowledge at the other, associating it with young people. If only for the reason that the moral baton as well as the baton of knowledge and ability is passed down from generation to generation. The main reason is that general principles of socialist morality unite people of different ages in socialist society. And they are the complete opposite of bourgeois morality. There indeed is a fundamental polarity at work here, and age does not play any role."

I feel that one cannot but agree with Peeter Saari. How are the educational and moral levels of the individual connected, how does this link change in time, from generation to generation? There are many different aspects here. The prominent Soviet architect, Andrei Burov, used to ponder why some modern architects, who were far ahead of the ancient masters knowledge-wise, were unable to rise to such heights as the Parthenon, the Church of the Intercession of the Virgin on-the-Nerl, and the Cathedral of St. Demetrius in Vladimir. "The artistic value of a work of any era," he wrote, "is determined not so much by the absolute level of knowledge as by the unity of knowledge embodied in the work, be it a house or a poem.

"The level of a folk craftsman may not be very high, but everything that surrounds him as the creation of his hands, as art, is fine, because it is in unity... Works wrought by human hands were fine when they were the total of all the knowledge of their times and were on the level of their times." <sup>1</sup>

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<sup>1</sup> A. K. Burov, *On Architecture*, Moscow, 1960, p. 76 (in Russian).

It is not a matter of the volume of knowledge, but of how intelligently and purposefully man has availed himself of the knowledge of his times, how strong in him are the thirst for integrity and the ability to harmonise the knowledge of his age. And not just in theory, but in practice, in implementing his ideas.

Of course, it is far more difficult to harmonise knowledge today than during the times of Ancient Greece or the Vladimir-Suzdal Principality. This harmony itself is embodied in quite different structures and ensembles. But it is along this line that comparisons can be made; it is along this line that traditions both in scientific and artistic endeavour are handed down from one age to the next, from generation to generation.

One can also speak to a certain extent about the harmonising of moral principles of the individual. It should not be forgotten for one minute, however, that morality is of a historical and, at the present stage, a class-oriented nature as well. For example, the purposes—humane or inhumane—for which new knowledge is used depend not so much on the level of knowledge as on the morality of which class is implemented by this individual voluntarily or involuntarily, or perhaps even forcibly.

What is also important is the stage of development of the moral views of the particular class we are dealing with. The bourgeoisie is now scuttling many of the principles which it promulgated back when it was young and on its way to power. And whereas Defoe's *Robinson Crusoe* was once an ode to the limitless potential of the human character, which the author identified

with the formation of the bourgeois character, today's ideological production of the capitalist class in its entire range—from philosophical treatises to the crime columns in newspapers—is becoming the apotheosis of the destruction of the individual, the cheapening of human life.

It is not fortuitous that quite a few “researchers”—self-styled scientists and “free-lance artists” have appeared in the United States and other developed capitalist countries who experiment on the lives of their fellow citizens, who are engaged in cognition in defiance of the law and all moral norms. In Los Angeles one of these “researchers” opened fire at an airplane on a runway. He didn't find anything criminal in what he had done. He was just doing research into the “aesthetics of the correlation between movement and space”. Another “free-lance artist” put a bomb under the famous Brooklyn Bridge in New York (only a faulty fuse prevented it from exploding). But he was of the opinion that this was not a bomb but a “kinetic sculpture”, and that he himself was not a terrorist but an “environmentalist sculptor”.

If these were isolated instances of psychological aberrations in separate individuals there would be no reason to make special mention of them. Unfortunately, they are frequently an extreme yet most consistent manifestation of the amoral policy being propagated and pursued in capitalist society.

This process of the destruction of morality and the destruction of the personality also affects the world of science. A Dutch TV network interviewed Samuel Cohen, the American physicist who invented the neutron bomb.

This man's replies, full of cynical self-satisfaction, reveal the fact that although he is well in command of the latest in physics, he is completely devoid of conscience, of a basic sense of decency.

For two decades he has worked on the discovery of the most inhuman weapon of mass destruction in history. When the interviewer asked him: "Didn't the thought 'What is it I have invented?' ever strike you over the past twenty years?" Cohen replied: "No, never. This weapon is much more accurate than any ever invented. This may sound like bragging, but, to tell the truth, this is really so."<sup>1</sup>

The capitalist way of life itself spawns such monstrous, perilous deviations from basic moral norms.

The picture is different in socialist society. Modern man living under socialism has inherited and is developing both the knowledge and moral experience accumulated by many generations. The thirst for integrity which urges a person to harmonise and make use of his knowledge of the world for the common weal also prompts him to regulate and harmonise his conceptions of good and evil, drawing on the entire moral experience amassed by humanity.

Socialist morality, as Lenin told the delegates to the Third Komsomol Congress, "serves the purpose of helping human society rise to a higher level and rid itself of the exploitation of labour".<sup>2</sup> It comes out resolutely against every-

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<sup>1</sup> *Literaturnaya Gazeta*, August 19, 1981.

<sup>2</sup> V. I. Lenin, *Collected Works*, Vol. 31, Progress Publishers, Moscow, 1982, p. 294.

thing that limits and destroys the working man's character and alienates it from society.

The principles enshrined in the foundation of the moral code of the builder of communism express the morality of the triumphant proletariat. But these principles also mirror conceptions of the morality of the entire Soviet people as well as the ethical ideals to which the toiling majority of humanity have aspired for centuries. It is for this reason that they are ethical beacons for all nations on the road to the future.

It is perhaps here that science, art and morality merge and work together as the individual liberated by socialism incessantly strives to know and improve himself and the world, in the name of happiness on Earth and in all corners of the Universe to be ultimately reached by people. They are united by a thirst for integrity, a thirst to harmonise all that man learns with humane principles...

There is a parable about a man who had found out why the sky is blue and where a rainbow comes from, after which he was no longer able to admire them, but just saw the "dry" laws of physics. But Peeter Saari, no matter how devoted he is to physics, would hardly be happy in a world where there is nothing else. Very indicative in this respect is his reply to a question asked by a correspondent of a Tartu city newspaper: "Do you feel that for a scientist everything not related to his science should be relegated to a position of secondary importance?" He answered: "Not at all. If physics were the only thing in my life, I would feel inwardly shackled in my life's choice. It's nice to cross the doorstep of the laboratory in the morning. But

it's also nice to cross the doorstep of my home at night."

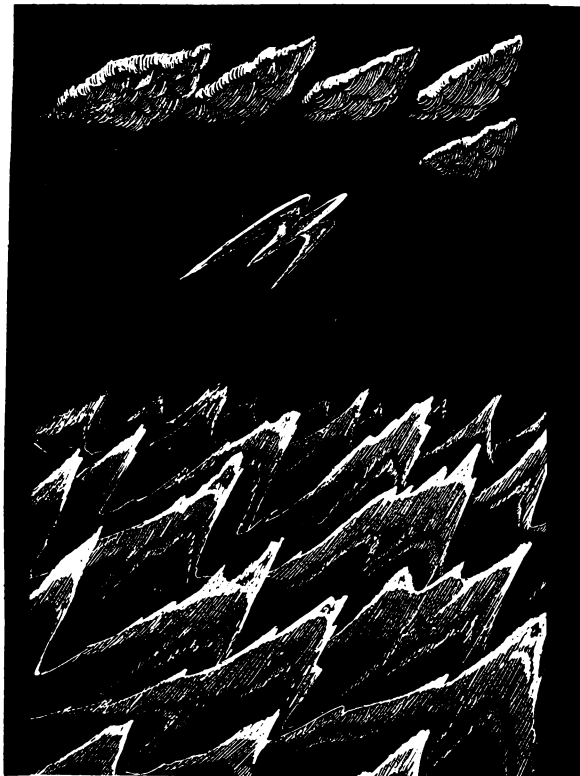
For a person who knows how each Estonian cherishes his home and family it is clear that just this equating of the laws of physics and the comfort of hearth and home implies a definite attitude toward the wide world, which is not confined to his laboratory or flat.

In the summer, he likes getting up early to see the sunrise. At dawn he pensively thinks about the main things in life and work.

The Lithuanian artist Stasis Krasauskas has a triptych entitled "Aspiration". Each of the black-and-white sheets contains just three elements—a man, a bird and the horizon. But they say a great deal. As long as man does not think about emerging from the vicious circle of the ordinary flow of life, submissively bowing in the shape of this circle, he will be very far not only from the ideal but also from the border line between dream and reality. Furthermore, his dream will also be far from this line. When a person begins to act, work and fight for an ideal, he himself approaches the horizon and brings his dream closer to it. Finally, when a person breaks the pull of the customary, he goes over into the world of innovation and discovery; when he crosses the horizon, reality becomes wonderful and perhaps surpasses the dream.

Firm let him stand, and look around him well!  
This World means something to the Capable.  
Why needs he through Eternity to wend?  
He here acquires what he can apprehend.  
Thus let him wander down his earthly day;  
When spirits haunt, go quietly his way;  
In marching onwards, bliss and torment find,  
Though, every moment, with unsated mind!

Goethe. *Faust*





THE REM KHOKHLOV LECTURE  
HALL

**“In marching onwards ... Though, every moment, with unsated mind,”** it was with these words Faust, who is not yet blinded and still able to see the world clearly, ends his monologue. **“Then dared I hail the Moment fleeing: Ah, still delay—thou art so fair!”**, he would admit this possibility later, already blind. I feel that it is this ode to eternal movement and the eternal thirst for knowledge that accords with the moral credo of the modern Soviet scientist.

*Question 40. Today one has to delve deeply to accomplish something important. No time is left for anything else. Real scientists are like that. Then why the frills, why the talk about diversity?*

*Question 41. We are giving the youth the ideal of the scientist to which we ascribe erudition and universalism. Later on they meet people in laboratories who are hardly Einsteins or Landaus. The very ideal is called in question. Aren't we losing a great deal in the aesthetic education of the young researcher by expecting too much of his moral potentialities?*

*Question 42. Whenever I encounter scientists who possess vast knowledge and feel a great deal more than their colleagues in science, the arts and life in general, I ask myself: what is it that drives*

*them other than the inquisitiveness natural to all of us? Is it a sense of duty? But they do not owe anyone anything, knowing as they do more than others in their field. Is it moral responsibility? To whom and for what?*

Essentially, we have discussed these questions above. To enlarge upon them I would select a form different from that in the preceding chapters. I will now talk about the character of a scientist, our contemporary.

In tradition-rich Moscow University there are not all that many lecture halls named after instructors. This honour is conferred upon scientists who not only left a momentous mark in science but were also particularly well liked at the University and well respected throughout the country and the world. One of the largest lecture halls in the University bears the name of Rem Viktorovich Khokhlov.

I would have liked to have invited him to converse with the readers on these pages. But there will be no dialogue in this chapter. I could have, of course, followed up the readers' questions with his genuine words – from published articles, interviews and conversations, and from my notebooks. They would, in effect, answer my questions. But my decision would have been incorrect not because Khokhlov was not actually asked these questions and did not answer them directly. The fact of the matter is that he, being a man of few words, would answer these questions not so much with words as with actions, with his civic positions and the charm of his personality. With his entire life.

Military leaders, artists, public figures and poets have indeed been the rulers of men's minds

over the centuries. Then scientists suddenly entered the picture in the mid-20th century. Well, not all that suddenly. In ancient times, in the Renaissance and in the modern period the scientist has always held rather great authority. But Claude Henri de Saint-Simon believed that "happy will be the age when ambition will begin to see grandeur and glory only in the acquisition of new knowledge and will abandon unclean springs with which it has tried to quench its thirst. They were the springs of disasters and vanity which quenched the thirst only of ignoramuses, heroes, and conquerors and destroyers of the human race."<sup>1</sup>

For which reason: "May they, abandoned by everyone, dry up and no longer stupefy the haughty mortals. Enough honour for the Ceasars! Long live the Archimedes!"<sup>2</sup>

It is for this reason that many young people today are more and more frequently measuring up their life's goals against those of such personalities as Igor Vassilievich Kurchatov, Mstislav Vsevolodovich Keldysh and Sergei Pavlovich Korolyov. This doesn't even require special explanations. However, the phenomenon of the dramatic growth in the prestige enjoyed by scientists implies more than rightful recognition of the great role being played by the scientific and technological revolution. It also contains the serious danger that the personality of a top scientist may be placed up on a pedestal irrespective of

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<sup>1</sup> Claude Henri de Saint-Simon, "Lettres d'un habitant de Genève a ses contemporains", *Oeuvres de Saint-Simon & d'Enfantin*, Vol. 15, Librairie de la Société des gens de lettre, Paris, 1868, p. 22.

<sup>2</sup> Ibid.

what kind of an individual he may be.

The few principles of propriety common to science and its "knightly code of honour" do not at all automatically and inevitably produce individuals with lofty moral qualities. Aside from any professional codes, a certain public-minded basis is essential for this. It is important that the personality itself be formed in a world oriented precisely to serving people and to opposing evil and coercion.

Without understanding this, it is difficult to explain the secret of how Rem Khokhlov, who was for many of the world's researchers a standard of a great, innovative scientist and a strong personality who attained his goals, won a different, far more difficult recognition—he was a moral standard for young people going into science and for mature people already working in it. Furthermore, he was by nature alien to any type of idolising. He never did anything to have legends spread about himself. He just lived. He worked. He remained himself. Or rather, he became himself, for in many respects he made himself into what he felt an ordinary person who respects himself and others should be.

A childhood friend once asked him: "What do you need the mountains for? What draws you to them?" Once when they were flying over the Pamirs the pilot asked him the same question. Khokhlov quipped: "What do you need aerial acrobatics for?" He answered his friend differently:

"See the wall over there?"

"Yes, so what?"

"Would you crawl up it to the roof?"

"What do you take me for?"

Khokhlov smiled: "That's a normal human reaction. It is impossible. But there are also hardly noticeable protuberances and cornices. A road can be found where there seemed not to be any. And this is darn interesting!"

Inside the lab and out he loved to search for and find these "protuberances" invisible to many.

There is a term in physics called nonlinearity. Take for example, an ordinary pendulum. When it swings slightly the dependence between the deviation from the balance position and the restoring force is directly proportional. The physicist would call it linear. But if the oscillation increases, if we are dealing still greater energy, the dependence becomes much more complicated. Rem Khokhlov was intrigued by precisely these – nonlinear – phenomena. It was with them that his work, which brought him world renown, was connected. But he as a personality does not lend himself to "linear" analogies.

He was used to overworking. But sometimes the overloads have transcended earthly bounds. This has happened quite often in recent years. Sharp wrinkles have appeared on his face and bags under his eyes. And Khokhlov's famous, good-natured smile of understanding of his companion and the world pierced through his leaden fatigue. His was then like the face of a cosmonaut under the overloads of the rocket launch. The face of a scientist contemplating the fundamental problems of existence. The face of a person who in the past 15 years compressed time and accomplished what others didn't in a lifetime: he went from Candidate of Sciences, one of thousands in the country, to Lenin Prize winner, Rector of Moscow University, academician,

acting vice-president of the USSR Academy of Sciences, member of the Central Auditing Commission of the CPSU Central Committee, deputy of the USSR Supreme Soviet, vice-president of the World University Organisation.

Many still could see him through a different prism those years, too. On July 15, 1976 an athletically built, tanned man wearing shorts, sneakers and a western shirt stood first at the morning roll call at the mountain climbing camp on a Pamyr glacier. He was amazingly youthful at that moment—he looked no more than 30. That's the way Rem Khokhlov was on his 50th birthday. It was hard to get to the jubilarian. One had to climb up four kilometres, to the starting point of the ascent to the country's highest peak.

Khokhlov had under his belt four ascents of peaks over 7,000 kilometres and the national title. He used to swim in ice-holes in winter. He went in for Alpine skiing. He used to run 20 kilometres at a clip. This was not jogging for purely health reasons, it was real long-distance running. Once when he was running by a field where students were playing football a first-year student shouted: "Hey fellah, kick the ball over here!" He was quickly admonished by his peers: "Quiet, dummy, that's the rector!"

His den at home is a cacophony of foliants of science books on shelves and a weight in the corner, a photograph of a mountain peak with clouds bunched up on its edges, and Picasso's "Don Quixote".

It would have been enticing to have used the well-known journalistic technique of drawing a portrait of a man and then another, completely

opposite one, and finally declaring that I was talking about one and the same person. Nevertheless something prevents me from simply putting two portraits next to one another—for the contrast to work. For deep down Rem Viktorovich Khokhlov was a very integral man.

He had a global, universal sense of landscape which is given to a person by open, light-bathed expanses, the violet sky over the summits, the oceans, bold, flight-suggestive architecture inseparable from the tense pace of life in big cities. Perhaps for this reason he considered Vancouver the most beautiful city in the world: the cliffs, the sun, the picturesque winding sea coast. Maybe this was why Moscow's Lenin Hills was his most cherished spot on earth.

He did not like introverted people who shut themselves off in their own little worlds, so it would be grossly incorrect to stereotype Rem Khokhlov as some "modern personality" who was "in a hurry to live", who looked spectacular but behind the showy dynamism was deeply "into himself" and shunned the complexities of life.

It was not Khokhlov's way to collect and amass things. He loved to give presents. He literally gave away all the reprints of articles on a wide range of scientific subjects that had been sent to him as rector. But he usually distributed them to people who needed them for their work.

He was eager to give a boost to new ideas, new projects, new people. And even though there were decades ahead for that fine brain (his life was tragically cut short at the age of 51), there were more ideas than could have been brought to fruition in one lifetime. He was in a hurry to



give these ideas to his pupils. He had an amazing intuition for “points of growth” in science and people.

A large poster hung over the blackboard in the old Moscow University building, in the lecture hall where Rem Khokhlov went to classes in his student years. It was the scale of electromagnetic waves – from radiowaves to gamma radiation. It seemed to many at the time that each region of the scale had its own specifics, and that methods of studying them were so different that partitions seemed to appear between these spheres which could not be crossed.

In those years Rem’s friends were crazy about atomic physics and even set up a fun science society,  $\Lambda\epsilon\mu\sigma$ . The four Greek letters symbolised four great physics problems: lambda – the length of the de Broglie line, the quintessence of quantum mechanics; epsilon – an electric charge; mu – mass; and sigma – spin.

Rem Khokhlov did not pick any of these problems, even though he was considered the hope of the department. He studied radiophysics, a boring, practical and down-to-earth field, as some of his university chums put it.

However, while working on his graduate thesis and in postgraduate school, he began developing, and developed, a method for approximately, but with a sufficient degree of accuracy, solving equations which describe nonlinear processes and are used in different sectors of the wave range. When he was studying the radiowave range and low-energy quanta, and was working purely theoretically on nonlinear problems, the time was already approaching for masers and lasers. And Khokhlov proved more

prepared than many others to work in this field, and not as a follower but a leader. It turned out that in his youth he had chosen the road which led him to the summits ahead of the others.

By applying methods they developed in radio-physics to the sphere of visible light and high-energy quanta, and in the environs of the atom, Rem Khokhlov, Sergei Akhmanov and their associates proved theoretically that if a laser beam is passed through a crystal of a special structure the interaction of strong coherent radiation with the substance can double or even triple the frequency. They built the first parametric light generator at Moscow University. By passing through a nonlinear crystal, red-light beam changed to green, which just yesterday had been considered impossible. A huge number of practical applications followed from this.

Rem Khokhlov is called one of the fathers of nonlinear optics. He and Akhmanov coauthored the first monograph in the world on its basics. The range of his interests, however, applied to virtually all of modern physics, from the nucleus of the atom to the interaction between nuclear physics and biology, from fundamental laws to new technological tasks, and embraced a wide circle of its most topical problems. I once asked him: "If you had to do it all over again what would you choose?" He said that he would go to Moscow University's physics department, but would choose biophysics.

He was a bright, wholesome individual who searched for common links not only between different spheres of physics, not only between different sciences, but also between humanitarian and natural principles in life. It is for this reason

that Vladimir Sofronitsky's performances, the works of the Impressionist School at the Pushkin Fine Arts Museum, and Nadezhda Pavlova in *Don Quixote* fit so harmoniously in his rationally organised world.

*Question 43. Today it is more customary to speak of the boldness of scientific thought. Are there scientists endowed with boldness in the original, masculine meaning of this word?*

During an ascent the group of mountain climbers Rem Khokhlov was in had encountered very inclement weather. It was raining and thundering. The bridges on the mountain rivers had been washed away. The alpinists' camps were closing...

They somehow managed to reach an abutment over which a cliff hung. For a long time they couldn't make up their minds whether to go to sleep or not, as the wind could fling them all into the abyss while they were asleep. Then Khokhlov said: "Why worry about it? We've led glorious lives and lived well. Let's go to sleep!" And he lay down first. Someone then asked him: "Rem, is there anything you're afraid of in this world?" He just grinned: "No, I'm not afraid of anything."

Many scientists are inveterate mountain climbers. It is interesting to observe the transformation they undergo in the mountains. Many change dramatically. They seem to lose all their inhibitions and shed civilisation with a passion. They become completely different people. And this is so natural!

Khokhlov didn't change. On Lenin Hills, in the rector's office, in the Pamyr Mountains, at night camp before the ascent, on the slopes – he

was one and the same man. Proper, reserved, considerate of others. There seemed to be no force in the world that could deprive him of his tranquility.

I once read an article whose author claimed, and reasonably so, that there are many types of boldness: civic, scientific, labour, boldness of thought and action. Rem Khokhlov was endowed with all of them.

Very many people are grateful to him for the fact that at difficult moments, when some preferred to remain silent and when speaking up was already tantamount to action, this generally quiet man would always speak his mind. That's the way he had been brought up. His parents had reared him that way—in an atmosphere of high morality, spirituality, responsibility to others. They belonged to the first generation of the Soviet technological intelligentsia; they joined the Party in the 1920s and gave their son a name which precisely mirrored the times: Rem—the Russian initials for “the revolution and the electrification of the world”. Rem and his wife Yelena were able to create the same atmosphere in their own family. Khokhlov's principle was: be yourself what you want to see your sons.

He was indeed endowed to the full with personal courage in the original, masculine, sense of the word. People could always count on him, in every way.

Once, when Rem was in postgraduate school, he was riding a suburban train. An argument broke out a few rows ahead of him; someone brandished a knife and many people in the carriage instinctively rushed for the doors. Khokhlov just as instinctively flung himself at the man

holding the knife and grabbed him by the wrist. At that time Rem wasn't the physically strong person he became later and whom everybody was accustomed to seeing in his later years. But this was already Rem Khokhlov.

Rem calmly crossed a mountain torrent on a log. He went skydiving without any preliminary training. He even arranged a tiger-hunting expedition, but it turned out that hunting tigers was against the law... What was this? Some felt that he was testing fate too much. Others said that he loved to try things out and experiment on himself.

If a student started improving upon a device which had already met the basic demands, Khokhlov would ask in amazement: "You are a bold person. Why perfect it? There are people who are specially equipped to do this and will do it better than you. Life itself will smooth over the rough edges. It is your job and mine, to look for them." When a cliff breaks apart all the pieces of rock are sharp at first. He loved these moments in science.

Khokhlov and Akhmanov set out to build a parametric light generator when this seemed technically impossible. There were neither powerful enough lasers nor good nonlinear crystals. Boldness was needed to get the project started. But Khokhlov needed more scientific boldness later, when he began research on the gamma laser. Not a single scientist undertook to make the first step, figuring that there were neither engineering nor purely theoretical calculations for approaching this problem, that at least several discoveries and a wealth of inventions had to be made prior to its solution. Rem

Khokhlov made up his mind to take the first step. Today the Soviet Union and the United States are conducting major research here, and he led one of the areas of study himself. When the gamma laser is created—and this will take much time and effort, when we perhaps learn to convert a chemical element into another on an industrial basis, and conduct operations with pencils of gamma rays inconceivable today (this “scalpel” will be able to penetrate not only the cell but also the individual molecule), and finally see the holographic images of molecules and atoms, people will then often remember with gratitude the name of Rem Khokhlov, the far-sighted scientist who initiated this idea and paved the way for it from semifantastic hypotheses to profound theoretical and experimental research.

*Question 44. Many scientists are extremely cautious in expressing their viewpoints. Is this a punctilious fear of inaccuracy or impropriety? Or is it a convenient “pose of silence” where one can remain on the sidelines of the struggle of ideas yet still hold to one’s ideas?*

If we are talking about genuine researchers, and not pseudo-scientists, whose categorical, sharp and “bold” interference in a controversy under any pretext in reality implies no time- and lab-tested viewpoint of their own, then reservedness and a sense of balance in judgments and in setting forth conclusions are indeed typical of scientists. This, incidentally, does not at all rule out the boldness of the conclusions themselves. This reservedness stems from the essence of research. And it harmoniously blended in with Rem Khokhlov’s character.

Someone once told me that Khokhlov met a cosmonaut during his vacation on Lake Issyk Kul. Rem spoke to him about the possibility of his making a space flight. The cosmonaut replied: "Go see Beregovoi at Zvezdny Gorodok (Star City) and talk it over with him." I heard that Khokhlov actually went to Zvezdny and spoke to Beregovoi.

I was in a quandary, as these were only stories. Not one documented proof. When I had a chance to visit Zvezdny, I asked Georgy Timofeyevich Beregovoi about this directly.

No, Rem Khokhlov had not spoken to Beregovoi about flying into outer space personally. He had come to Zvezdny twice in his capacity as Moscow University rector to decide specific questions. He examined the computers there together with Georgy Stepanovich Shonin and engineers from the Cosmonaut Training Centre. He advised them which computers they should choose. He asked many questions, all the while guiding the conversation towards practical issues: "How can Moscow University be of assistance to you?" Beregovoi noted that the University's mathematicians could be of great help to Zvezdny. Khokhlov promised: "Fine. We'll do something about it." Beregovoi recalls: "I was somewhat amazed by the thoroughness with which he inquired about the preparations for flights. He asked cosmonauts about many details concerning the body's adaptation to weightlessness and to normal earth conditions after the return to Earth.

"Today, now that I know that Khokhlov was an athlete and a first-class mountain climber I can well realise that Khokhlov dreamed about

flying in outer space. Moreover, the pointedness of his questions convinced me that that was the case. He had grounds for this, of course. After all, his conditioning as an alpinist would have helped him through the altitude chamber and many other trials on the way to the launching pad.

“As I realise today, a clear-cut logical thread could be traced in Khokhlov’s questions about the cosmonauts’ training. I got the impression that despite his outward softness he was tough in making decisions and in attaining his goals. But, I repeat, at that time Khokhlov and I did not concretely talk about a possible space flight by him.”

What I was apprehensive of most was contributing to another legend. So I had misgivings about whether it would be worth it to write about this encounter in Zvezdny. But I decided to write about it anyway. After a talk I had with a friend of Khokhlov’s, Corresponding Member of the USSR Academy of Sciences, Dmitry Vasilievich Shirkov.

I approached the topic delicately. But he understood what I was getting at: “Yes,” he said, “Rem told me that he would not be averse to going up into space. He even showed me exercises for training the cosmonauts’ vestibular apparatus, which he included in his own physical fitness programme. But his idea was only in the bud. He was accustomed to weighing his plans over a thousand times in his mind, obtaining the complete information and only then taking a decision as to whether to set about a project or not. So it’s senseless to talk about this idea of his categorically. He did not yet take a final deci-



sion. He was only sizing up the task. It had been a distant dream for him.

"Rem could not offer his interlocutor a still 'unprocessed' idea, one out of line with real potentialities. Yet it is within the realm of possibility that Khokhlov's first testing of his potential as a scientist-cosmonaut entered into his plans. He had the strikingly masculine trait of coming up with an idea, soberly weighing the pros and cons, and bringing it to fruition."

*Question 45. One can admire the harmonious individual that Academician Khokhlov was. But did he have the right, being a world famous scientist and a "national treasure" in a way, to scale summits and take risks, realising full well that he was an example for the young and that many would emulate him?*

I could imagine Rem Khokhlov's mischievous smile were he to hear such high-flown words concerning his character. Nevertheless, the question itself is a serious one.

When people say that Khokhlov was a fine athlete they are correct. He was indeed a sports devotee, he liked the spirit of competition and was always drawn to sportsmen. He enjoyed reminiscing about the time he spent at Zoya Mironova's clinic where he underwent a cartilage operation (the result of one of many football games) and met many famous athletes. He was a fan of the Spartak team. But he loved to take part in sport, and not just watch from the sidelines.

Once, as Moscow University rector and academician, he visited an army unit which the University "sponsored". He was shown the exercises and the military sports training the servicemen

undergo. At the end the students and soldiers started fierce competition to see who could do the most pull-ups. The commander was stunned when Khokhlov went over to the bar and did more pull-ups than the others. When he came to the city of Gorky, where he was supposed to deliver a report on the gamma laser, Rem immediately got together with local "human walruses" and went swimming in ice-holes in the Volga.

Even though he didn't like coming in second at competitions and was a born leader, Khokhlov was never an athlete with the mentality of a professional. He was first and foremost a highly cultured man, and he viewed sport as one of the most effective vehicles for forming the character, for surmounting not only physical difficulties.

What drew him to mountain climbing? What did he get out of these nights spent before the final drive to the summit, with their rap sessions and songfests? Why did he breathe so easily on the Fortambek glacier, where Suloyev Meadow lies elevated like a cup over the foothills of neighbouring 7,000-metre peaks and avalanches crash downwards, to the edges of this cup, stirring the sun-bathed snowdust?

All these questions acquired a troubling meaning in hindsight, for it is a fact that death befell him after a difficult ascent of one of the highest peaks in the country. The moment he felt ill he complained to no one, but gave his last ounce of strength to help another on the tough descent. There were the hospitals in Dushanbe and Moscow. He lived a few more days.

The mountain Khokhlov climbed then stands 7,495 metres above sea level. This time he didn't

make it by 200 metres, or the height of the Moscow University building on Lenin Hills. If you look from the foothills of the university at the spire and star atop it, the distance will seem impressive. But on a photograph of the peak it is a small, hardly noticeable stretch. Such was the thickness of the snowy mantle on that, the glacial plateau at an altitude of six kilometres, from which the helicopter picked him up in August 1977. The pilot set a world record: no one had ever taken off from such an altitude. But this was a bitter record. It would have been better if he had never set it.

In the past, too, Khokhlov was unlucky with this peak. In 1970 he was stopped right before the summit by a long blizzard. It was so bad that the climbers held the tent down with their bodies. Rem Khokhlov was the only one who thought they should go on. But that was physically impossible.

In 1976 nothing prevented him from reaching his goal. However, on the way they encountered a group of foreign mountaineers which was in distress, and they helped it descend.

One would like to see such people as Rem Khokhlov keep away from 7,000-metre peaks. For they are truly "national treasures" whom young people indeed look up to. And scaling a giant mountain entails not only a strong will and courage, but also risk, danger, chance and unforeseen circumstances. But if he hadn't attempted 7,000-metre peaks, it wouldn't have been Rem Khokhlov, but somebody else.

The enigma which he took away with him was what indeed mountains were for him: a release from everyday tensions, as some say; a scientific

problem, as others claim (he did much to train Soviet alpinists for Mt. Everest, and when asked one day at the Film-Makers Club to speak on this theme, he spoke precisely about the connection between alpinism and science); quenching the thirst of risk, as still others say; and the literal expression of his desire to tackle important, tough tasks and elevate himself to their level, as still others assert. Or a fusion of all of this. He opened up different facets of his personality for different people at different times.

Perhaps the following statement by Akhmanov is closest to the truth, or at least my perception of it: "When he went skiing in the mountains with his friends, there often was good weather, a bright sun, but he seemed to be lacking something. When it is windy and snowing many people don't like to ski, but these conditions were right up his alley. He liked it more with snow and wind. This applied to life as well as the mountains. I rarely saw him relaxed. He always had to be surmounting something, every minute.

"His character required tension. Tension lived in him, he never let it go. He set both for himself and those around him not only the level of a problem but also the level of thinking. It was not by a strong will alone that he made himself what he was but also by the fact that he kept his brain in tension all the time, he was ahead of his time".

If he had not been so stubborn that summer about climbing that mountain he undoubtedly would have accomplished much more. This is the most important "if" of the many suppositions which we can now formulate in hindsight. Just as if Gagarin had not made that last flight,

he, not a smiling photograph, would be with us today. But was there anything on earth that could keep Gagarin from flying or Khokhlov from climbing mountains? They say that he was a disciplined sportsman and obeyed orders. Perhaps this was so. Probably it was. But there wasn't an order in the world that would force him away from mountains once and for all.

He found office work dull; it cramped his style. He could not but broaden his horizons, thus he could not help reaching for the summits and high speeds. There was some deep, inner dissonance between his aspirations and the measured, slow course of life. Yet each gesture of his, each sincere movement was coordinated with the circle of people near to him and with the world in general. He liked the fact that in this fast-paced world he was able to fully control his actions and be in charge of the situation rather than being swept up by the stream of life.

Many people said he was an excellent driver and loved to speed. But he knew how to break just as skillfully. The main thing is to be lightning-quick with the brakes, he used to say. They said Rem Khokhlov liked to take risks. But wasn't his risk that great inner calm when a person is truly in the driver's seat and is able to control any difficult, quickly changing situation, and feels strong enough to do so? It is sometimes hard to determine from his actions and decisions where the risk is and where the boldness to make a decision is.

Rem Khokhlov's boldness was an important, integrated part of his character. The audacity of his actions was combined with boldness of his ideas, a thirst for integrity and for the new, with

the ethical foundation of his character—his “I take the responsibility” principle. And he did take full responsibility for his decisions. He knew how to work and do things in such a way that the others around him gave their all as well. However, he believed that a scientist should not be turned into a machine, that human principles of organising science were essential, and that a person should not be given assignments that deform the character. Nor should the individual weigh himself down with such tasks.

*Question 46. Why does a big organiser of science need tact? I am not too sure that such people as Kurchatov and Korolyov were very tactful people. Still, my respect for them has not lessened. By the very nature of their work they had to be people with tough characters.*

*Question 47. It has been written about Academician Khokhlov that he was very considerate of others. How was this possible in our stress-filled, businesslike times?*

We should leave doubts about Kurchatov's tactfulness on the conscience of the author of the question, who for some reason counterpoised firmness of character to tact towards others. There are many stories and legends going on about the “toughness” of Korolyov's character. Legends are frequently one-sided and only deal with the person's outer shell! Let us listen closely to the opinion of a man who knew Korolyov well: “He cherished his time very dearly. He was very dry, laconic and precise in discussing business. Nor did he tolerate a namby-pamby attitude in his colleagues. One could indeed get the impression that he was aloof, far removed from worldly life, that he did not entertain normal

human feelings towards others. But this is completely untrue.

"At the Moscow Higher Technical Training School Sergei Korolyov delivered a course of lectures and was always attentive to his students' needs and held long conversations with them. He could cut short his work and take the time for a nice chat with a person who had retired from his enterprise. He got involved in these people's lives. Finally, the head designer had a subtle understanding of his subordinates' moods; he could perk them up and calm them down. I witnessed the Belyayev-Leonov flight, when manual landing was employed for the first time and the cosmonauts did not land in the target area. A search got under way and we were all worried. We sat in a hall, while Korolyov was in the monitoring room, where he maintained contact with the search service. It was in this tense atmosphere that he put aside his extremely important matters for a moment and came over to us rank and file and said: 'Don't worry, comrades. The craft has landed safely. Helicopters have located the crew's whereabouts...'"<sup>1</sup>

What they write about Academician Khokhlov being a "standard of propriety" is true. Of course, how he attained this is also reason for serious reflections on the moral foundations of the character of a major organiser of research in our day.

Once, during a discussion on whether a director should be tough or soft, he noted: "I am against the collective throwing up of hands in different directions. A director should be a rea-

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<sup>1</sup> *Komsomolskaya Pravda*, March 21, 1981.

sonable dictator. If you don't have what it takes upstairs, no matter how you show the stuff you're made of, whatever stern measures you take, work will fall apart. And if a person is smart, he will do the job, and without bureaucratic highhandedness. The latter, incidentally, is often a cover for mental impotence."

He was a good listener. He listened to academician and student alike, with equal, sincere, and not diplomatic attention, as if urging them on: "Go ahead, tell me more, this is very interesting!" I experienced for myself his charm in full measure. Many could speak finer than he, but he was still great to talk to.

His co-workers even berated him: "You don't have the right to give equal time to those who come to you with work-related problems and those who come to you with nonsense." He would smile and throw apart his hands, but would continue doing things his own way. Apparently, there was something important, understandable to him alone and uncommon to the people who worked within his rough routine that existed in these endless and closely listened to confessions, requests for advice or support, and suggestions for improving particular facets of university life. He deeply understood how people long for a kind word or sympathy.

Rem Khokhlov never raised his voice, not even in the most dramatic situation. Perhaps only his family knew how exhausted he came home on Thursdays after his reception hours as deputy. He took other people's problems too close to heart. His boundless energy combined with a deep sense of respect and consideration for others.



How does one dramatically speed up the flow of life and the active transformation of the world without deforming the human soul, the character? Rem Khokhlov gave his all to answer this question in practical terms. It is perhaps for this reason that his students and co-workers listened so closely to his strikingly simple words that in the years when the world was engulfed in debates about knowledge and morality his life was a convincing argument in favour of the lofty morality and humanism of Soviet science merged with advanced ideas and ideals. He belongs to the young generation of academicians and, as an inimitable individual, mirrors the finest qualities of this generation in keeping with the on-going traditions of Soviet science.

*Question 48. Young scientists frequently are rough on their predecessors in that they strive to alter everything. How can this contradiction be resolved, how can the experience of the older generation be utilised without closing off the road for the young?*

I visited Academician Ivan Georgievich Petrovsky's office in Lenin Hills several times. Later I was in this office without Petrovsky and talked with Khokhlov, the new rector. The uncommonly young man who met me at the door, sat next to me and looked me straight in the eyes with a polite smile that involuntarily forced me to look around the room. Outwardly, the modern, Spartan interior seemed more suited to this man. But absolutely everything here, from the bright autumn landscape dated 1940 and autographed "Nesterov" (Petrovsky liked this artist very much), remained just as it was in the Academician's time.

When he became rector, Khokhlov, with a sense of filial devotion, saw to it that the traditions of his predecessor were carried on at Moscow University. This was more than a tribute of respect. He was fully establishing his own principles: fundamental knowledge and relevance to today's scientific needs as the bedrock of university education, the development of comprehensive research, unending, lifetime education. He believed that in the future colleges and universities would come to embrace not only young people, but would become centres of culture and education for the entire nation. But these were the principles of Academician Petrovsky. They were like-minded people.

I was once deeply impressed by a thought of Academician Pavel Sergeyevich Alexandrov, namely, that a person who works at a university is endowed with eternal youth. Every year in the lecture hall he meets a new generation of students, and the eternal spring of youth is forever repeated for him. After all, a person must have qualities which enable him pass the never-ending exam year in year out in front of new, ever younger (alas, one's own years pile up!) generations. Rem Khokhlov felt fine among young people. And young people felt fine with him.

He drew young people, and talented ones, too, to himself with uncommon ease. He didn't want, nor could he wait, for that matter, for youngsters to reach his level. He gave them their start in science. Those who began in science together with him were even a little jealous of the upper-classmen in "their Rem's" department when he would have long conversations with them about things which hardly loomed in the distant per-

spective, although they well realised that he was interesting people with whom he would jointly be tackling research problems of the eighties, nineties and the early 21st century.

For this reason the best memory of him is the university lecture hall, where the continuity of the times is effected, where generation after generation of students will come to search for answers not only to physics and mathematical analysis problems, but also to the eternal questions on how and what a person should be.

This lecture hall means a lot to me. I once attended my first physics lecture here. And many more after that. At one of them I learned how a laser beam is born. I found out about the Archimedes student festival before I saw him on the steps of the physics department. I made new friends. And I heard for the first time the name Rem Khokhlov, from them. It still wasn't in the textbooks and encyclopaedia then. He was just this nice man at the physics department.

Service and faith secure the individual life.

Goethe. *Faust*



**“HE ONLY EARNS HIS  
FREEDOM AND EXISTENCE,  
WHO DAILY CONQUERS  
THEM ANEW”**

It was late autumn in Berlin, and the air smelled of burning coal. This odour even seemed to penetrate the hall of the theatre created by Bertolt Brecht, where a production of *The Life of Galileo* was on today. It also accompanied me later, when I was returning to the Neva Hotel in the wee hours of the morning. My path took me past a small shop with Brecht's picture and books in the window and past the fence of the cemetery where he is buried. Even though each step brought me farther from the moment when the curtain fell, this finale was returning me to the theatre and I could hear in my mind the actors' voices all over again. Even today I can't explain for sure why my return to the language of my beloved Goethe, Heinrich Heine, Thomas Mann and Brecht occurred precisely in those minutes, at night on a deserted street in Berlin. The return was a lengthy one. I had far to go—from the war times when we refused to learn German in school because Hitler spoke that language.

Suddenly, on the Berlin night I palpably felt the insurmountable inner, moral opposition to fascism on the part of all times and peoples that was capsulised in this, Brecht's most philosophi-

cal play. And it is not at all fortuitous that the great German writer chose the character of a scientist to be the touchstone for his irreconcilability...

Through thorns to the stars. It has been that way all through the ages. And today, too. Choosing innovation means choosing life in one's full force, finding the happiness of creative endeavour. But this also means dooming oneself to a hard fate. There never were well-trodden paths to discovery. And people traversing new roads will frequently appear in the mirror of everyday "common sense" as some lost eccentrics who are "ruining their lives" themselves.

For a decent Philistine the eccentric has always been an antipode, for he has cast stones in the stagnant swamps of narrow-mindedness and "disturbed the peace" where immobility seemed to have settled forever. However, if one breaks with the norms of this "common sense", and looks more deeply into the innermost secrets of life, its development from the lowest forms to the highest, into the laws governing social and scientific and technological progress on Earth, he will in fact realise that "eccentrics", inventors, innovators and Don Quixotes are a very important mainspring of progress. They not only "adorn the world" but help it to advance. Ivan Turgenev was most certainly right when he said: "Without these ridiculous Don Quixotes, without these eccentric inventors mankind would not move forward—and the Hamlets would have nothing to reflect upon."<sup>1</sup>

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<sup>1</sup> I. S. Turgenev, *Collected Works and Letters* in 30 volumes, Vol. 5, p. 346 (in Russian).

It is very important to understand that the true road to the future is paved through the energetic efforts of science today. The realisation of this objective reality is the watershed which separates scientific prophecy from pseudo-prophecy, from speculation in science. It is a watershed beyond which science ends and pure rubbish – I apologize for the word – begins.

Incidentally, there are people who declare this road to well-nigh be an element of human culture. The magazine *America* once featured an article by E. Otman entitled “The Implacable Youth: Their Features, Idols and Ideals”. The author wrote: “...when there are such books as *Lord of the Rings*, the trilogy of the British writer John Tolkien, who needs history or *Hamlet*? This fairy tale for adults about war and espionage which engulf the mythical country of ‘Mediterrania’ contains material for many years of pseudo-research work...”

It may seem at first that the author is writing all this with poorly concealed sarcasm and is poking fun along with the reader at such best-sellers after which “who needs history or *Hamlet*?” But he is driving at something else, and in the meanwhile is tossing an idea up to the reader: listen, perhaps all this is not so senseless? Since this is so, since somebody likes this, there is some sense to it? Indeed, the summing up of the content of Tolkien’s trilogy is put as follows: “... this contrived world is quite captivating for students who want, at least for a while, to get away from wearisome realities.” Further on, having realised that all this might be rubbish after all, the author refers in all seriousness to the view of the American philosopher Alan



Watts: "A culture which does not dare carve a nook for pure nonsense is a dead culture."

So this is it: without nonsense culture (and science is an important component of it) dies. And many scientists with their "crazy", quixotic ideas confirm this with their lives. But what an abyss really lies between this nonsense, between the merchants' counters at the foothills of the Everest of science, and the "strange" picture of the world which opens up from its summit! The "strangeness" of science is an inevitability. Daniil Semyonovich Danin expressed this idea precisely in the title of his book: *The Inevitability of a Strange World*.

We all know the story about the woman who, after a lengthy explanation of how to operate the automobile, then only recently invented, says, "Now I understand everything. But where do you hitch up the horse?" Things usually don't reach such anecdotes, but how many discoveries we know of that were originally received even by the scientific community in the same vein!

Nevertheless, genuine science, no matter how unusual the new information it obtains about the world may seem, had nothing in common either with different types of chimeras or with the nonsense that "peppers" culture, for science always proceeds from actual laws and is based on them.

The application of the teaching of Marx, Engels and Lenin to social practice has engendered transformations of reality which at different stages of the history of the Soviet state have been elevated by friends and foes alike to the rank of a "miracle". The fact that the Soviet Republic, gripped by hunger and dislocation, emerged victorious against the intervention of 14

powers was called a miracle. The same was true of the first five-year plan. And the rout of fascism, to which Europe had capitulated... And the flight of Yuri Gagarin, the world's first cosmonaut...

Are there too many miracles? Doesn't the clue lie not in the inexorability of the "strange", but of the new world? This inexorability has long been expressed clearly and incontrovertibly by Lenin in well-nigh mathematical terms: "... it is the class struggle, and not my very best wishes, that will determine the building of a new Russia. My ideals of building a new Russia will not be chimerical only if they express the interests of an actually existing class, whose living conditions compel it to act in a particular sense. By thus adopting a stand for the objectivism of the class struggle, I do not in the least justify reality, but, on the contrary, indicate in this reality *itself* the deepest sources (though they are invisible at first sight) and the forces that can transform it."<sup>1</sup> Born not in polemics on knowledge and morality but in Lenin's reflections on the destiny and future of his homeland, these words are nevertheless a model of a high moral position in science and provide a key to the formation of the scientist's moral code.

Repeated attempts have been made in history to create such a code. Ludwig Feuerbach, for example, prescribed the following precepts for the researcher: 1) a scientist is a courageous fighter for truth, but himself possesses a peaceable character; 2) a scientist is also compliant, it

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<sup>1</sup> V. I. Lenin, *Collected Works*, Vol. 18, Progress Publishers, Moscow, 1973, p. 330.

is more important for him to learn than always to be right; 3) a scientist goes his own way, he delves into his own subject without looking to the right or left; 4) a scientist knows no other enjoyment than working and being effective; 5) a scientist is simple and accessible, and is far removed from pride and self-importance; 6) a scientist has no time for evil, distrustful thoughts; 7) a scientist does not covet worldly honours and riches, he finds happiness in science; 8) honesty is the main virtue of a scientist; 9) a scientist is an objective person; and 10) a scientist is a person free of himself.<sup>1</sup>

You will agree that this code predetermines much of what present-day science should be guided by and is guided by in actual practice. According to these precepts, a scientist must be a courageous champion of peace. They also say so many mitigating words about compliancy that the thought unwittingly occurs to one as to whether Brecht's irreconcilability doesn't conflict with Feuerbach's kindness...

Today there are the world of socialism and the world of capitalism on the planet. There exists the confrontation of their political and philosophical positions and their moral principles. And kindness, justice and truth have to be safeguarded in the tough struggle of ideas.

When mention was made in David Gilbert's presence of Galileo's lack of firmness (a reference to his famous "betrayal" of Copernicus), Gilbert objected: "But he was not an idiot. Only an idiot could believe that scientific truth needs martyr-

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<sup>1</sup> See *The Marxist Ethic*, Moscow, 1980, p. 274 (in Russian).

dom—that may be necessary in religion, but scientific results prove themselves in due time.”<sup>1</sup> Max Born, who witnessed this conversation, wrote: “Statements such as these guided me on my path in life and in science.”<sup>2</sup> And not only him, but many Western scientists as well. Fascism in his homeland and the atomic blasts in Hiroshima and Nagasaki were a bitter lesson for the scientist. Toward the end of his life Max Born, objectively rejecting the path he had once chosen, became actively involved in the fight for peace.

The controversy continues today, too: if we view Galileo’s famous refusal not as concern for the salvation of his own life but as one of the ways of fighting for scientific truth (it is more flexible and diplomatic than the rigidity of Giordano Bruno), then how rightful is this path? Which is better: to defend your views fanatically or agree to compromises in the full knowledge that your viewpoint will stand the test of time, that it will emerge victorious anyway?

Life is merciless in this regard. It does not tolerate duplicity and demands a single choice. If the choice is an honest one, it requires courage. And it engenders courage. That is its essence. And one should not sidestep it, indulging in talk of “compromises for the sake of truth”. Naturally, in research, when actual possibilities are weighed, when collective decisions are adopted and implemented, one has to reject something

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<sup>1</sup> “Recollections of Max Born” (I. How I Became a Physicist), *Bulletin of the Atomic Scientists*, September 1965, Vol. 21, No. 7, p. 4.

<sup>2</sup> Ibid.

and make concessions. Ideas, however, even if they are promising, are not established by themselves. They are established by people. And someone has to stick his neck out. Is it going to be you or not – this is the important thing. There is your conception of honour. There is a sense of duty.

That's the way it has always been in science. One can, of course, reject formally the idea of the endlessness of the galaxies or the "heresy" of the Earth's revolving around the Sun and wait till somebody else comes along... But you can't reject yourself. Getting back to Brecht, he wasn't even talking about Galileo with his contemporaries, and continues to talk with us today. He was talking about our moral choice. And the writer's reply is mercilessly uncompromising as regards the memory of the great Italian scientist who really lived on Earth. The researcher's compromise with his conscience, not even for the purpose of saving his own life but as "one of the paths of struggle for scientific truth" destroys his character and impedes others in their search for truth.

A scientific discovery seldom has anything directly to do with the moral criteria of the age in which it has been made. Yet, the very discoveries of Copernicus, Galileo and Bruno could not but cause fierce ideological and moral conflicts. For these discoveries were made in conditions not isolated from the world, they were made by people who were living in society and were not absolutely free of its impact. Whereas objective truth is "indifferent" as to how society will perceive it, society itself is not indifferent and cannot be indifferent to the new truths taking shape within it.

Let us suppose that the Earth revolves around the Sun is a fact which doesn't depend on the existence of the Holy Inquisition of the late 16th-early 17th centuries. But the Holy Inquisition, that watchdog which guarded the ideological foundations of society at the time, was unable to perceive this truth as anything other than an impingement upon this foundation. The reason was that "the truth can lead anywhere", as one of the heroes of Brecht's *The Life of Galileo* says. Any religious faith is permeated with this fear of truth, of cognition.

This is history, however. What's the situation like in our day? In the mid-20th century a chain nuclear reaction could be obtained with equal probability in the laboratories and on the testing grounds of a socialist and a capitalist country. The very fact of the spontaneous splitting of atomic nuclei is "indifferent" to society. But society is not indifferent to this fact. It is bourgeois society and its leaders that jumped at this great discovery and immediately used it for inhumane purposes.

Herein lies its "logic", the "logic" of a world based on the exploitation of labour and on private ownership (unless we are talking about different historical stages of this world). The Inquisition could not but burn Giordano Bruno at the stake or force Galileo into renunciation, or also burn him in case he did not consent. In another century, the 20th, the richest capitalist state, surmising that it is a monopolist and that it can act with impunity, had, by dropping atomic bombs, committed a crime against humanity and humanism.

At the present juncture it is clear to everyone,

except people who are completely naive politically, that the atomic blasts that destroyed Hiroshima and Nagasaki were not so much a strike at militarist Japan, which was doomed to surrender soon anyway, as the start of nuclear blackmail against the Soviet state, against the society that had brought the world new truths.

The socialist state had to prove that such threats made against it were senseless and useless. Soviet atomic weaponry had to be built to offset the American bomb. And the big research-team headed by Igor Vassilievich Kurchatov handled this task. So many plays, film scripts and memoirs have already been written about the history of the Soviet atomic project that it would probably be superfluous to recount it now.

Mention should be made, however, as to why this was a feat, why this was the loftiest manifestation not only of scientists' civic duty but also of their moral duty to humanity. The reason is that at issue was curbing the aggressive plans of the most reactionary, the darkest forces on the planet and preventing them from pushing the fatal nuclear button. Who knows, if Soviet science had not effected this feat peace might not have been preserved over the bulk of the planet for the forty years since the Second World War.

The lesson of Hiroshima is a cruel lesson, showing as it did that capitalism is capable of casting entire cities into the atomic conflagration just as the Inquisition threw individual heretics into the flames. This lesson showed that capitalism has arrogated itself the right to "punish" entire nations, just as the church once assumed the right to take away the lives of its opponents.

And there are other lessons as well. One of them is the parable about Galileo which Bertolt Brecht addresses to his contemporaries, to people living in the 20th century, to you and me. The point of this lesson is also cruel, and simple: there is no price which can make the scientist betray truth and genuflect before the forces of evil. There is only one honest answer to evil in the world—to oppose it. There is one way of fighting for scientific truth—to defend it to the end.

Moral problems of science do not exist separately from science itself, from the scientist's life's work. They cannot be set apart as some "dry residue". So it is naive to conceive of scientists as people who spend their leisure sitting in front of their synchrophasotrons and philosophise on the drama of Galileo and the tragedy of Faust.

Inasmuch as "My worthy friend, gray are all theories and green alone Life's golden tree," (Goethe, *Faust*) the same is probably true in personal instances. Nevertheless, the principle of morality permeates all of science—its rare hours of glory and its everyday hard work behind the scenes. It is in connection with scientists' work that this book is dealing with the moral problems encountered in the world of research and researchers. For this reason transitions of such reflections are necessary from moral aspects of the use of scientific breakthroughs to the essence of these breakthroughs themselves, from the moral aspect of the scientist to his personality and to the galaxy of individuals that make up today's research teams.

Indeed, with rare exceptions, modern science



is not the domain of brilliant individuals but the endeavour of big research teams. This is a feature of science all over the world. And all over the world this feature is giving rise to a set of fresh moral demands of relations between the individual scientist and the organisation in which he works. But it is socialist society that by its nature and its principles provides actual conditions enabling the individual and group to function jointly and conflict-free.

It would be an oversimplification to state that research communities based on mutual trust and respect cannot arise in the bourgeois world. Suffice it to mention the international family of scientists at the Cavendish Laboratory when it was headed by Ernest Rutherford. But we would be far from reality if we did not realise that capitalist society as a whole alienates the individual from tackling common problems and cultivates individualism and isolation. And if under capitalism scientists do pool efforts to tackle important research tasks, this inevitably takes place not out of a sense of collectivism, cooperation and mutual assistance, but on the basis on which an ordinary capitalist enterprise works. This spawns many acute moral contradictions between the individual researcher and the research machinery, of which he is a more or less important cog.

One feature of science in bourgeois states is the rather frequent incongruity between the noble intentions of scientists engaged in research and the inhumane application of their findings, which does not depend on the scientists themselves and is dictated by the interests of the monopolies. This state of affairs is generating

protests on the part of the most honest Western scientists. Some of them even demonstratively leave active research. Several, like Max Born, focus on the social aspects of research work. However, while recognising the important role such protests play in the formation of the moral principles of modern science, it should be realised that the conflict between the individual honest researcher who professes humane ideas and the principles governing scientific work in a capitalist state is predetermined by the very foundations of this state.

The controversy over whether cognition destroys the integrity of the human character or, on the contrary, ensures it, becomes less concrete outside the context of society to which this question is addressed. Giving their energies to sciences, the finest sons of humanity believed over the ages in the good of knowledge. But over the ages the dominant classes turned knowledge into evil, to man's detriment, and hid it from the masses. For this reason the stand of many of the sceptics who, drawing on the latest knowledge and using the language of modern science, are today, too, propagating, as is stated in the Book of Ecclesiastes, the idea that the multiplying of sorrow is "programmed" into the multiplying of knowledge, entails both the bitter experience of history and the present-day practice of using scientific breakthroughs in the capitalist world.

Soviet science pits a different moral precept against this stand. The man of the future, who is already being formed in socialist society, will harmoniously combine intellectual, moral and aesthetic principles in his character. He will make cognition one of his principal needs and

will combine it with productive labour, which will transform the face of the Earth and will for ever turn the compass of science to the side of good. And this is not some abstract ideal. It is already a reality, embodied in the destinies of many of our contemporaries and marked in the annals of science with the names of prominent scientists whom the Soviet people are proud of and whom humanity will always be proud of.

In place of precepts dictating the bounds which man cannot cross, our times and socialist society have advanced and are establishing a moral code for the builder of communism. It represents not restrictive bounds but the core of the individual living to the fullest, irradiating all his knowledge, abilities and talents into the human environment and receiving great moral satisfaction from serving others.

Moral bans in society based on class inequality are becoming a thing of the past. However, this process is not taking place peacefully, but amidst a vicious struggle. In this struggle science is one of the strongest destroyers of the morality of the exploitative society, which holds the masses in check, while the high priests of this morality, as Heinrich Heine put it, "secretly drank their wine while preaching water publicly".

Science is socialism's ally in debunking hypocritical capitalist moral "precepts". This alliance is indeed mutual, for it is socialism that removes the "brand of the devil" from science and enables it to truly become moral and to serve genuinely humane interests.

Marx, Engels and Lenin repeatedly rebuked those who, in connection with the Communists' rejection of bourgeois morality, accused them of

rejecting morality altogether. While delving into the theories of morality current in his time in *Anti-Dühring*, Engels analysed the relative and absolute in man's conception of good and evil. "Which, then, is the true one?" he wrote. "Not one of them, in the sense of absolute finality; but certainly that morality contains the maximum elements promising permanence which, in the present, represents the overthrow of the present, represents the future, and that is proletarian morality."<sup>1</sup>

Today this morality is being established in diverse manifestations of the Soviet way of life. In the Soviet state the morality of the triumphant proletariat which rightly inherits and expands upon the humane norms of morality developed by humanity has become the moral code for the entire nation, of all its segments, including the country's large scientific community. It is socialist society that is providing the scientist with a real opportunity to work without betraying his conscience, as research and its findings in this society serve humane ideals and goals. Hence the main moral precept of Soviet science: conscious service in society's interests, the unity of the professional and the civic in the scientist's character, and the desire to give all one's energies and knowledge for the benefit of others.

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<sup>1</sup> Frederick Engels, *Anti-Dühring*, Progress Publishers, Moscow, 1975, pp. 113-14.

## Epilogue

Two great processes are changing the face of the world today: the national liberation of the working people initiated by the October 1917 Revolution and scientific and technological revolution. These processes are closely connected and inevitably appeal to the conscience of the scientist; they demand an unequivocal answer to the question of what is the ultimate goal of his unlocking the mysteries of nature.

If he is sincere before his conscience, if he realises his responsibility to his contemporaries and those that will come after him, his personal experience and the experience of the generations before him, the age of search for truth and of wandering in the labyrinths of ignorance and his emergence from them to the light will inevitably lead him to the position which Faust reached as his moral summit and which Soviet scientists profess openly and honestly – both in science and in the complex socio-political realities of the 20th century:

He only earns his freedom and existence,  
Who daily conquers them anew.

Eternal struggle, eternal search and eternal  
establishing of truth and good and their unity...

By some strange coincidence, I am penning

these last lines in Leningrad, the very place where the idea struck me to write the book. There is an hour and a half left before the train leaves. I bid farewell to the sphinxes. Their lips pursed and pupils dilated, they are looking into the shadows, like people who have forgotten their tormenting past and are trying to recall it. The look on their faces is somehow associated with the troubled rolling of the Neva's waves by the granite steps. This movement, which does not lend itself to clear-cut, ready explanations, seems strange and mysterious in the twilight. It is hard to explain in words, but even if the world stopped the Neva's waters would still go on rolling. Eternal motion is like a warning to the complacent and a reminder that man will have no tranquility either in the world of silence or the world of formulas or the world of big cities where there are now cold days between the falling of the leaves and the first snow.

Where does knowledge lead—does it benefit man or will it prove to be his undoing? This controversy between Faust and Mephistopheles in Goethe's *Faust* is a sort of key to this book by the Soviet journalist Kim Smirnov. Reflecting on letters sent in by his newspaper readers, the author talks to outstanding Soviet scientists—Academics Victor Ambartsumian, Yevgeny Velikhov and Bonifaty Kedrov, to name but a few—about the interdependence between the socio-political and moral positions of the researcher, what ways he can or cannot take to reach the truth and his moral courage.

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